Presented at the ACEEE 1986
Summer Study, Santa Cruz CA, August 1986

LBL-21741

FINANCIAL IMPACTS OF ENERGY CONSERVATION INVESTMENT IN PUBLIC HOUSING

Evan Mills
Ronald L. Ritschard
Charles A. Goldman

Applied Science Division
Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

(415) 486-4802

July 1986

The work described in this report was funded by the Assistant Secretary for Conservation and Renewable Energy, Office of Buildings and Community Systems, Buildings Services Division of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

ABSTRACT

In recent years, the Department of Housing and Urban Development (HUD) has strongly urged local public housing authorities (PHAs) to improve the energy efficiency of their building stock in an effort to reduce upward-spiraling energy costs. Local public housing authorities can fund conservation measures with: (1) HUD Comprehensive Improvement Assistance Program (CIAP) funds, (2) general operating subsidies, (3) utility-sponsored conservation financing programs, and (4) third-party investments. In this study, we examine the relative financial impact on HUD and PHAs of these four funding strategies, based on case studies of actual retrofit efforts by two local housing authorities: San Francisco, California and Trenton, New Jersey. The selected retrofits all show significant energy savings. This is not, however, reflected in the financial benefits to each party because current provisions of the Performance Funding System (PFS) for public housing energy subsidies require that costs and savings associated with energy conservation retrofits be shared between HUD and the local housing authorities, regardless of the financing mechanism used.

Under the present PFS rules, HUD benefits substantially from all four retrofit projects. The local PHA also receives positive economic benefits in two cases, a solar domestic hot water system financed by third party investors and a high-efficiency boiler replacement financed with CIAP funds. In another case, the San Francisco Housing Authority weatherized 1827 apartments with a zero-interest loan from the local utility and plans to pay the loan back over eight years out of general operating subsidies. The present value of loan payments ($124/apartment unit) exceed the value of lifetime energy savings ($78/unit); thus the retrofit has an overall negative financial impact on the Authority. In our last example, the Trenton Housing Authority is adversely affected (-$315/unit) because of ongoing maintenance costs associated with a heating control retrofit which are not reimbursed by HUD.

Our results indicate that the provisions of the PFS often result in a net loss to the local housing authority, while HUD enjoys substantial benefits. This occurs even for conservation measures with payback periods less than three years; hence the present policy reduces the incentive for PHAs to invest in conservation projects that are very cost effective from the "societal" perspective.

KEYWORDS

Energy Conservation, Space Heating, Residential Retrofits, Monitoring, Economics, Public Housing, Energy Policy, Third-Party Financing

INTRODUCTION

Since the U.S. Housing Act of 1937, the federal government has constructed some 1.2 million public housing apartments, which provide shelter for 3.4 million low-income and elderly persons (Perkins and Will, 1980). Public housing management is under the auspices of the U.S. Department of Housing and Urban Development (HUD), which provides 2,700 local public housing authorities (PHAs) with technical and financial assistance in planning, developing, and managing low-income housing. The annual operating budget for each PHA (including anticipated energy costs) is established by HUD through a subsidy framework, based on projected needs and available funds.

Local PHAs began experiencing energy-related budgetary problems during the late 1970's because of the rapid escalation of energy prices after the "oil embargo" of 1973. Other factors also contributed to budget woes: first, most housing projects were built between the late 1940s and the 1960s when energy was cheap and energy-efficiency was not a consideration in building design. As a result, these older structures generally use more energy than comparable structures built today. Second, the Brooke Amendment to the Housing and Urban Development Act of 1969 established regulations that limited rental income to a fixed percentage of the tenant's income, not to exceed 25%. Recently, the ceiling was raised to a new maximum of 30% (Ferrey, 1986). These regulations, which were designed to relieve the financial hardships of low-income residents, produced budgetary difficulties for local housing authorities as rising operating costs outpaced rent revenues. In 1975, HUD responded by formally adopting a Performance Funding System (PFS) intended to provide each PHA with subsidies needed for efficient project management. In addition, they sponsored a major study of public housing conservation potential (Perkins and Will, 1980).

The HUD study concluded that rising operating costs were a major problem for local PHAs. Specifically, the study noted that nominal energy costs in public housing had increased 400% since 1970, and would continue to outpace general inflation over the next few decades. The current administration, however, has taken the position that rising local energy prices will not be reflected in future federal budget allocations. As a result, utility bills will increasingly be paid out of local maintenance and administrative funds. Deferred maintenance adds to project deterioration, which in turn may lead to increased energy demand.

During the last several years, public housing authorities have attempted to control rising energy costs by initiating retrofit projects (Greely et al., 1986). They have used various sources to pay for these conservation measures, including: (1) HUD Comprehensive Improvement Assistance Program (CIAP) funds, (2) general operating subsidies, (3) utility-sponsored conservation programs and (4) third-party investments (e.g., from energy service companies). In this study, we examine the impact of these various financing strategies on the distribution of retrofit savings and costs between HUD and local PHAs. We discuss deterrents to energy conservation that result from the current regulatory framework, and report results from four retrofit projects undertaken by two local housing authorities, San Francisco and Trenton.

DESCRIPTION OF RETROFIT PROJECTS

Table I provides background information on the four projects. In San Francisco, the Housing Authority took advantage of a utility-sponsored, zero-interest loan program to install attic insulation, exterior door weather stripping, low-flow showerheads, and water heater blankets in many of the projects that it manages. The loans could be used for both material and labor costs and were repayable over an eight-year period. We studied five low-rise multifamily housing projects that are master-metered and occupied by families. These five projects include roughly 25% of the apartments managed by the Authority. Retrofit costs ranged from $80 to $200 per apartment unit, with an average of $124/unit (1985$). For each project, utility bills and the number of occupied apartments were available for approximately three years, including one year after retrofit. Weather-normalized annual consumption declined by an average of 14.9 MBtu/unit after the retrofit, or 13% of pre-retrofit energy use (Goldman and Ritschard, 1986).

Solar domestic hot water systems were installed at six senior, low-rise properties managed by the San Francisco Housing Authority, where domestic hot water is supplied by central boilers. This relatively expensive conservation option ($546/unit) was financed by third-party investors, who own the solar equipment and sell hot water to the Housing Authority in a micro-utility arrangement. We calculated energy savings based on Btu-meter readings of the energy produced by the solar system for a one year period after installation (Atkielski, 1986). Savings averaged 6%.

The Trenton Housing Authority installed heating system retrofits at two projects, Haverstick and Donnelly Homes. At Haverstick, central boilers that supplied space heating and domestic hot water were replaced with modular high-efficiency, condensing-pulse combustion boilers (Gold, 1986). The Housing Authority used CIAP funds (provided by HUD) to finance this rehabilitation/retrofit project. The initial capital costs for the high-efficiency boilers were approximately $1,775/unit, $550/unit more than estimates received by the Authority for a conventional boiler replacement. Energy savings were calculated based on six months of weekly readings taken after the retrofit. Savings were dramatic, almost 50% of pre-retrofit gas consumption (Greely et al., 1986).

At Donnelly Homes, the Trenton Housing Authority used CIAP funds to replace central boiler heating controls. The new control system varies the pressure in the steam distribution network by regulating control valves in each heating zone's steam line, depending on outside temperature. Initial costs for the retrofit were around $460/unit; annual maintenance expenses are not expected to exceed 10% of the initial cost.* Annual oil consumption declined by 17% after the retrofit (Greely et al., 1986).

* Maintenance expenses were estimated by Chaim Gold, a consultant for the Housing Authority.

Except for the solar DHW system, the simple payback period, calculated as cost of the retrofit divided by the dollar value of the first-year energy savings, is under three years. Neglecting tax benefits and rebates, the solar domestic hot water system will take over 18 years to pay for itself. To determine the *actual* benefits to each party, however, we must consider the Performance Funding System.

RETROFIT SAVINGS UNDER THE PERFORMANCE FUNDING SYSTEM

The Performance Funding System is used to determine subsidies for public housing operating costs, including a separate subsidy for energy costs, known as the "Allowable Utility Expense Level." The subsidy is designed to meet anticipated energy costs in the coming year by combining expected consumption and price for each fuel. The following aspects of the system are important for assessing the distribution of retrofit savings between HUD and the PHA (HUD, 1977).

- Until 1983 the energy subsidy was based on average consumption during a fixed period (i.e., 1973-1976). Currently, it is based on a "rolling base" period—average consumption during the previous three years. As a result, reductions or increases in energy use are incorporated into the subsidy in years following the retrofit.
- If actual and predicted consumption levels differ, the balance is shared by HUD and the housing authority on a 50/50 basis—if surplus funds are available at HUD.
- As part of the year-end accounting, actual consumption is adjusted for weather severity using heating degree-days in a "typical" year.
- HUD fully reimburses the PHA for unanticipated increases in utility bills due to increases in fuel and electricity price—again, reimbursement is made only if funds are available. Correspondingly, the PHA must return funds to HUD if it overestimates price increases.
- In the event of fuel switching or meter conversion, the rolling base consumption figure is adjusted to fully reflect the new fuel price and consumption in the first year after the switch. The correction must be based on estimated energy use until the rolling base fully incorporates the actual change (if any) in consumption by year five. Purchased solar energy is treated as a new fuel.
- The burden of any new maintenance costs associated with a retrofit are paid by the PHA out of general operating expenses. Future subsidies do not reflect this increase.*

* John Casper, HUD Regional Office for Public Housing—Region IX. General operating subsidies are based on expenses in a base year during the early 1970s, and adjusted annually for factors such as inflation but not for new expenses for existing buildings. Personal Communication.

Although they stand to recapture most of the resulting savings, HUD currently does not assist PHAs in contracting with third-party energy service companies. In *shared-savings* arrangements with third-party investors, the firm is ordinarily paid out of the energy savings; however, under the PFS rules, the PHA does not retain enough of the energy savings required to pay the firm (Sherman, 1984). In *micro-utility* arrangements the firm sells energy to a housing authority at prices below those of the fuel they replace; savings from the new fuel (even solar) are immediately recaptured by HUD under the fuel switching clauses in the PFS.

METHODOLOGY

Following the PFS rules, we calculate the net present value (NPV) of each conservation investment to HUD and the local PHA. As an economic indicator, NPV is useful because it can be applied whether or not a given party incurs costs that offset energy savings.

For retrofit projects capitalized by HUD, the cost is subtracted from the present value of HUD's share of energy savings. When the housing authority pays for the retrofit out of its general operating subsidies, we subtract the cost from the PHA's energy savings to reflect the net cash flow effect of diverting funds from routine operations to conservation. We represent the societal perspective by combining the costs and benefits for all parties. If third-party investors pay for the retrofit, the capital cost is incorporated only in the societal cost/benefit calculation.

We first determine energy savings by analyzing utility bills or actual meter readings for at least one year before and after the retrofit, using the Princeton Scorekeeping Method (PRISM) to normalize for differences in weather severity (Fels, 1986). When possible, we adjust for variations in occupancy rates. We then apply the PFS rules to find the percent savings distribution for each party in post-retrofit years. We assume a six-month lag time between retrofit installation and the utility billing periods included in the rolling base. The result represents the combined effect of the three-year rolling base and the 50/50 sharing of savings. The percent distribution in year "i" is given by:

$$\text{HUD savings fraction}_i = 0.50 * (S_i - C_i) + (SR_i)$$

$$\text{PHA savings fraction}_i = 0.50 * (S_i - C_i)$$

where the annual subsidy, S, is calculated from the rolling base and consumption, C, is actual consumption in year i. HUD also recaptures funds via subsidy reductions, SR, as the rolling base declines. The net effect of the PFS rules is that a one and one-half year payback time is required if energy savings retained by the PHA must be used to offset capital and/or maintenance costs.

The following assumptions were used in the economic analysis:

- energy price escalation rates: from DOE regional forecasts (DOE, 1985)
- inflation: 3%/year
- discount rate: 10%/year (before inflation)
- retrofit lifetime: 15 years
- maintenance cost escalation rate: 4%/year (before inflation)

RESULTS

Under the present PFS rules, HUD benefits substantially from all four retrofit projects, including the two in San Francisco, for which it did not supply the initial capital (see Fig. 1). However, two cases show a negative financial impact on the local housing authorities: weatherization financed through a utility-loan program and heating controls paid for with HUD CIAP funds. The components of costs and benefits for each of the case studies are presented in Fig. 2 and the net results in Table II.

The SFHA retains only only 10% of the total savings from weatherization (see Fig. 3). In addition, the Authority repays the zero-interest loan from operating expenses, without reimbursement from HUD; the SFHA's lifetime energy savings are $78/unit versus $124/unit in loan repayments, hence the overall negative financial impact on the SFHA.

Complex financial arrangements are involved in the third-party financing of solar domestic hot water systems in San Francisco. The SFHA arranged to purchase the hot water at a 10% discount from the price of the gas it replaces; purchased solar hot water is treated as a new fuel under the Performance Funding System. We assume that the collectors are donated to the SFHA in year ten (based on information in the prospectus offering). From that point onward HUD enjoys free hot water, and thus savings become far more substantial. The investment favorably effects HUD as the cost of the solar collectors is borne by third-party investors. Despite the SFHA's initiative in securing non-federal funds to finance efficiency investments, the SFHA receives none of these benefits because the fuel switching rules in the PFS immediately adjust subsidies downward to reflect the decreased fuel costs. The Authority's benefits result instead from special rebates offered by the local utility and modest lease payments from the investors for rooftop areas occupied by the solar collectors. The collector costs are $546/unit, versus the present value of $129/unit in energy savings. Accounting for these costs (but ignoring the availability of solar tax credits and special utility rebates) produces a negative societal benefit.

The CIAP funds provided by HUD for high-efficiency boilers and heating controls in Trenton, which cost roughly $1775/unit and $460/unit respectively, result in net savings, for HUD, of $4200/unit and

REFERENCES

R. Atkielski, San Francisco Housing Authority, personal communication, 1986.

Interim rule. 24 CFR Part 890, *Annual Contributions for Operating Subsidy—Performance Funding System,* September 13, 1983.

U.S. Department of Energy, *Energy Prices and Discount Factors for Life-Cycle Cost Analysis,* Prepared by the National Bureau of Standards, November 1985. NBSIR 85-3273. Tables Ca-2 and Ca-9.

U.S. Department of Housing and Urban Development, *Performance Funding System Handbook,* 1977, with updates in 1982 and 1983.

M. F. Fels, "PRISM: An Introduction," *Energy and Buildings, 9:1,* 1986.

S. Ferrey, "Cold Power: Energy and Public Housing," *Harvard Journal on Legislation,* Vol 23:33, 1986.

C. Gold, "The Pulse Combustion Heating System at Haverstick Homes," *Proceedings of the ACEEE 1986 Summer Study,* Santa Cruz CA, 1986.

C. Goldman and R. Ritschard, "Energy Conservation in Public Housing: A Case Study of the San Francisco Housing Authority," *Energy and Buildings, 9:1,* 1986.

K. Greely, C. Goldman and R. Ritschard, "Analyzing Energy Conservation Retrofits in Public Housing: Savings, Cost-Effectiveness and Policy Implications,", *Proceedings of the ACEEE 1986 Summer Study,* Santa Cruz CA, 1986.

Perkins and Will and the Ehrenkrantz Group, *An Evaluation of the Physical Condition of Public Housing Stock: Final Report,* H-2850, U.S. Department of Housing and Urban Development, March 1980.

J. Sherman, "Using ESCo Programs in Public Housing," *National Association of Energy Service Companies (NAESCo) NEWS,* March/April 1984.

Table I. Building and retrofit descriptions.				
Housing Authority	**Trenton**	**Trenton**	**San Fran.**	**San Fran.**
Projects	1	1	5	6
Dwelling Units	376	112	1827	388
Building Type	Low-rise[a]	Low-rise	Low-rise	Low-rise
Retrofit Measure	Heating Controls[b]	High-Eff. Boilers	Weatherization	Solar DHW
Retrofit Year	1981	1984	1982	1984
Retrofit Cost ($/unit)[c]	458	1,776	166[d]	546[e]
Financing Source	CIAP	CIAP	Utility Loan	Third Party
Space Heat/DHW Fuel	Oil	Gas	Gas	Gas
Fuel Price ($/MBtu)	6.00	6.70	5.10	5.10
Maint. Cost ($/unit-yr)	40	-10[f]	0	2
Annual Energy Savings (MBtu/unit)	26.1	95.4	14.9	5.7[g]
Simple Payback (yrs)	2.9	2.8	2.2	18.8

[a] "Low-rise" is defined as three or fewer stories.

[b] Steam traps and vacuum pumps were also installed.

[c] Costs expressed in 1985 dollars.

[d] Nominal retrofit cost. The present value of the 8-year loan payment is $124/apartment.

[e] Cost borne by third-party investors, not subtracted from HUD or PHA savings.

[f] Maintenance cost *reduction* based on more reliable, new boilers.

[g] Savings based on measured PHA purchases of solar hot water from the micro-utility; solar production includes an assumed 60% boiler efficiency.

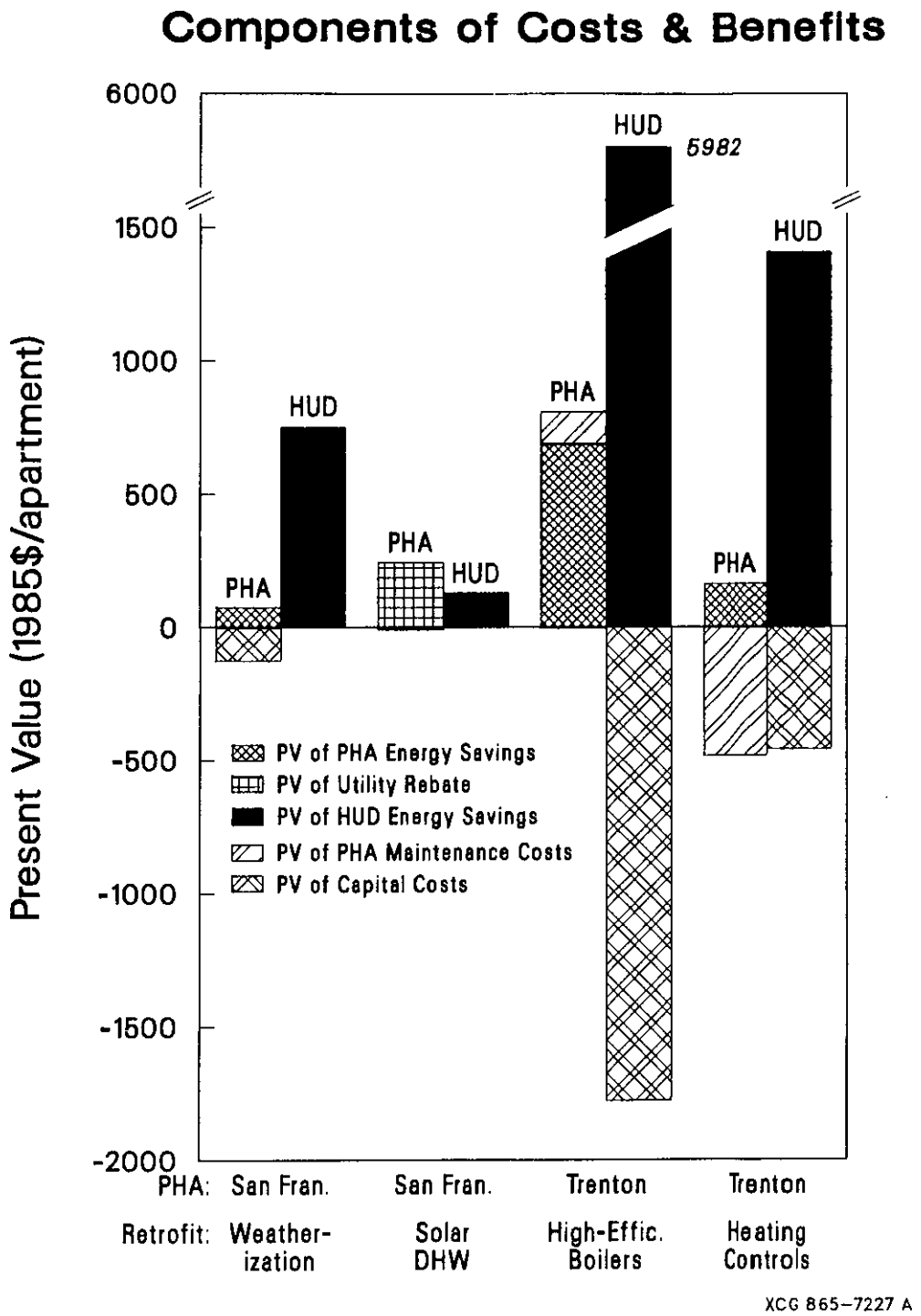

Figure 2. Present values of energy savings, associated capital and maintenance costs, and utility rebates for each case study.

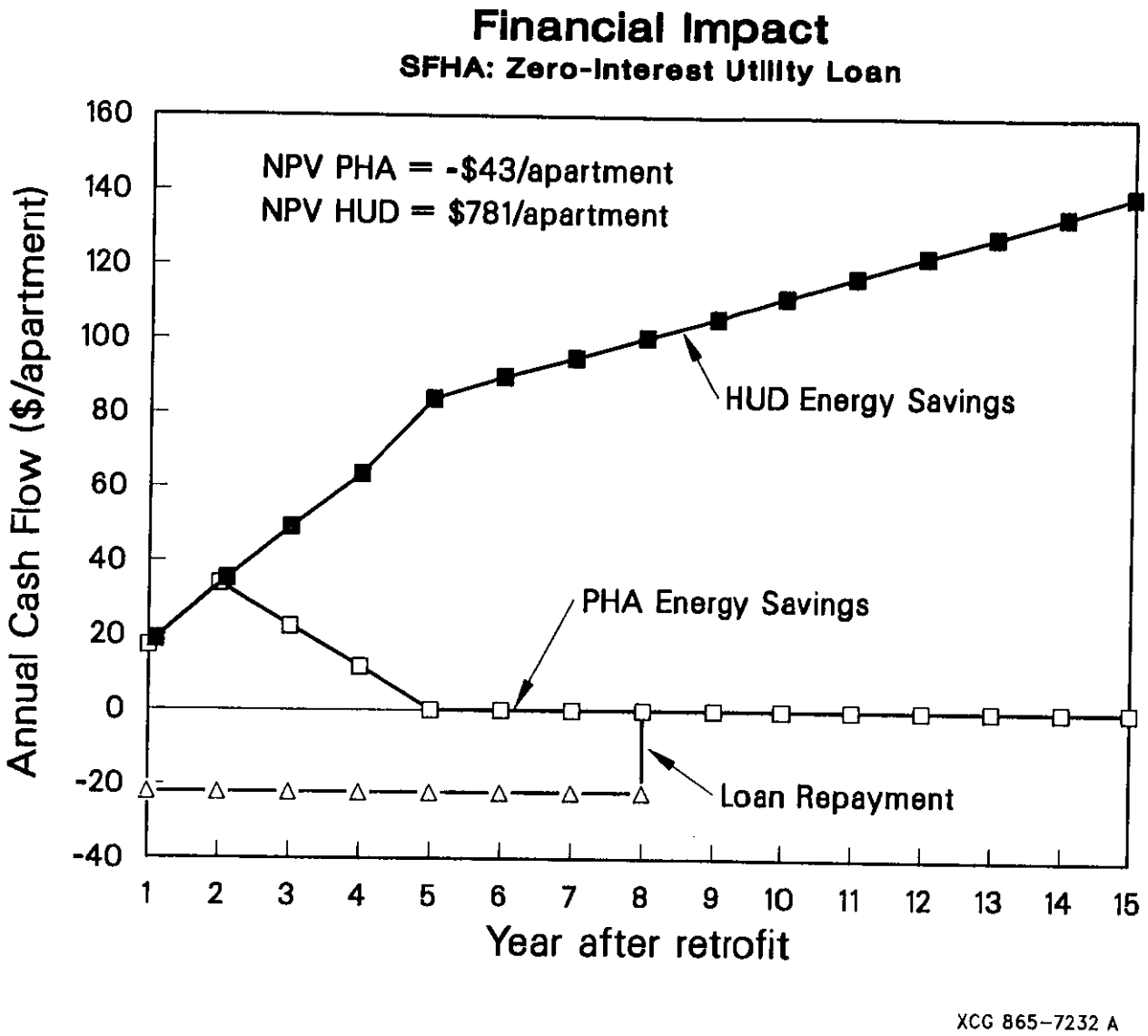

Figure 3. Financial impact, over expected life of the retrofit, on HUD and San Francisco Housing Authority of the zero-interest loan weatherization program. The loan payments exceed the Authority's energy savings.

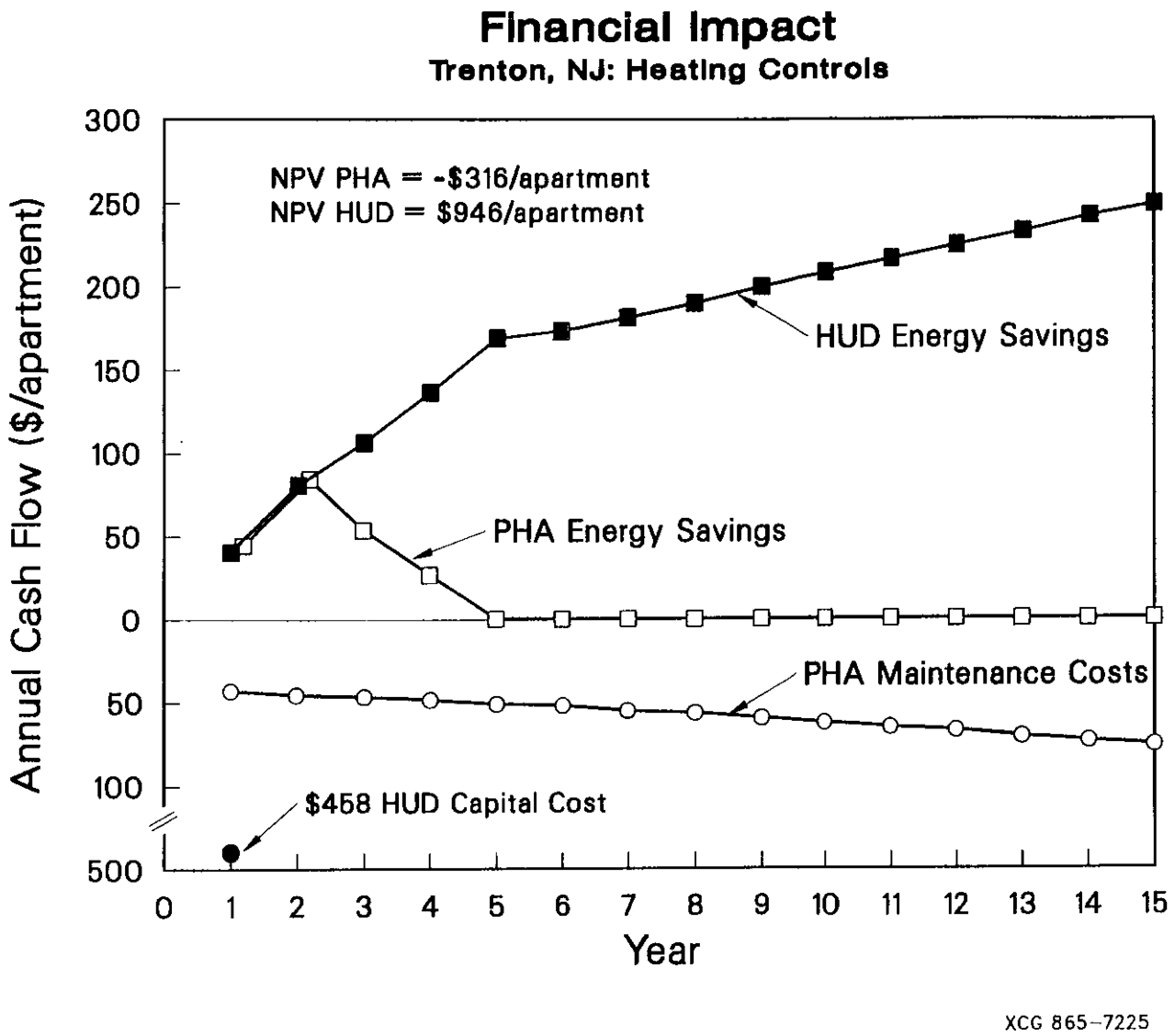

Figure 4. Financial impact, over expected life of the retrofit, on HUD and the Trenton Housing Authority of the heating controls retrofit. Note the negative impact on the PHA of high maintenance costs. The present value of maintenance costs is $482/apartment unit, well above the $165/unit energy savings received by the PHA over the retrofit lifetime.