



Closing the Split-Incentive Gap: A Comparative Analysis of Subnational Financing Mechanisms for Deep Energy Retrofits

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Abstract. Deep energy retrofits in U.S. affordable multifamily housing face persistent financing barriers despite favorable lifecycle economics, compounded by the owner-tenant split-incentive problem and constrained capital budgets. With federal grant programs disrupted in 2025–2026, durable subnational mechanisms—Commercial Property Assessed Clean Energy (C-PACE), utility on-bill financing, and state green bank programs—become central. This paper develops a comparative analytical framework applied to a 60-unit pre-1980 mid-rise affordable multifamily scenario in U.S. Climate Zone 5, calibrated against Connecticut Green Bank FY2024 portfolio data (405 closed C-PACE deals; 127 multifamily program projects across 7,094 units) and triangulated against New York and federal HUD program benchmarks. A 30-year net-present-value cash-flow model and a five-criterion scoring matrix evaluate each mechanism and two paired-instrument combinations. Three findings emerge. First, mechanism choice and split-incentive resolution are of comparable importance at realistic policy ranges: under typical Section 8 Project-Based Voucher (PBV) utility-allowance pass-through ($\kappa \in [0.3, 0.7]$), mechanism choice moves owner net present value (NPV) by $\approx \$417\text{K}$ while varying κ moves it by $\approx \$354\text{K}$. Second, only 6.7% of Connecticut's closed C-PACE portfolio is multifamily—empirically confirming HUD/CHFA mortgage-consent friction. Third, NYSERDA on-bill alone is the policy-focused scoring leader and ties Combo B (Green Bank + On-Bill) for the equal-weight lead, but its \$5,000/unit cap leaves substantial owner equity to be sourced elsewhere; combinations dominate where that equity gap cannot be closed.

Keywords: Affordable housing finance; Split-incentive; C-PACE; On-bill financing; Green banks

1 Introduction

Affordable multifamily housing in the United States faces a recurring paradox: deep energy retrofits frequently demonstrate positive lifecycle value^[9] yet uptake remains constrained by financing and governance barriers rather than physical or economic

feasibility. The owner-tenant split-incentive—owners pay for retrofit measures while tenants paying utility bills capture the savings—weakens the owner's investment case [2]. Residential rental households consume $\approx 28\%$ of U.S. residential energy, 88% pay all energy costs directly, and the split-incentive accounts for at least 1.89% of total U.S. energy use [2,7]. Affordable housing operators additionally face constrained capital budgets and complex regulatory environments raising transaction costs.

Three subnational mechanisms aim to close these gaps: C-PACE attaches retrofit financing to property tax assessments via a senior non-accelerating lien [5]; utility on-bill financing repays through utility-bill line items, structurally aligning with the split-incentive [1,8]; state green banks—operating in roughly two dozen U.S. states [3]—offer credit enhancements, gap financing, and below-market loans [4]. All three are state- or utility-administered and therefore durable across the federal grant-program disruptions of 2025–2026. By holding the underlying project constant, the analysis isolates the effect of financing structure on owner net benefit, tenant outcomes, and program scalability.

2 Scenario and Methods

2.1 Scenario Specification.

The scenario is a pre-1980 mid-rise (4–7 story) affordable multifamily building of 60 units, regulated under the Low-Income Housing Tax Credit and/or Section 8 PBV programs, in U.S. Climate Zone 5, undergoing a deep retrofit (envelope, cold-climate heat pump electrification, water-efficiency, rooftop solar where feasible). Connecticut is the primary reference jurisdiction because the Connecticut Green Bank operates all three mechanism types with publicly documented portfolio data; the NYSERDA on-bill program is adopted as the closest documented Northeast on-bill analog, since Connecticut lacks a comparable multifamily on-bill program. Table 1 reports calibrated parameters.

Table 1. Calibrated scenario parameters.

Parameter	Value	Source
Units	60	—
Climate zone	5 (Northeast)	—
Retrofit cost	\$1,350,000 (\$22,500/unit)	[4] Table 166; [6]
Pre-retrofit utility bill	\$180,000/yr (\$3,000/unit/yr)	[2,6]
Post-retrofit savings	32% = \$57,600/yr	[6,10] NYSERDA tier 3
Horizon; discount rates	30 yr; 3% / 5% (headline) / 7%	OMB A-94 mid-range
Default PBV pass-through (κ)	0.30	[11] HUD HCV Guidebook

2.2 Financing Mechanisms.

C-PACE is modeled on Connecticut C-PACE terms calibrated to the 12-year portfolio average (5.68% rate, 18-year tenor) across 405 closed deals [4,5]; the statutory Savings-

to-Investment Ratio (SIR) > 1 requirement is a binding eligibility constraint. **LIME Loan** is the Connecticut Green Bank Low-Income Multifamily Energy loan (~6.0% rate, 20-year tenor) administered through Capital for Change CDFI, requiring ≥60% units serve households at ≤80% AMI [4]. **NYSERDA on-bill** caps multifamily financing at \$5,000/unit or \$500,000/building over a 15-year tenor at ≈4% [1] — \$300,000 for this scenario.

2.3 NPV Model and Scoring.

Annual owner cash flow is $CF^t = \kappa \cdot S - D^t$, where κ is the owner share of gross savings S and D^t is year- t debt service; for on-bill, debt service falls on the tenant utility bill. Default $\kappa = 0.3$ reflects PBV utility-allowance pass-through with the multi-year adjustment lag prescribed by HUD HCV utility-allowance methodology [11]; immediate post-retrofit periods commonly see κ near 0 before allowance updates, while aggressive allowance reform could move κ toward 0.7. The 5% discount rate is the headline anchor (OMB Circular A-94 mid-range, typical affordable-housing operator hurdle); 3% and 7% are sensitivity bounds. Each mechanism receives a 1–5 score against five criteria; because all owner NPVs fall in the same absolute bracket, Owner NPV is scored rank-relative within the comparison set (5 = best). Formal multi-criteria decision-making methods (AHP, TOPSIS) would strengthen weight-selection objectivity in future work. Two paired-instrument combinations are evaluated: **(A)** C-PACE for 80% of project cost as senior tranche plus a Credit Enhancement Fund (CEF)-backed bank loan for the remaining 20%; **(B)** LIME+CEF for envelope/HVAC plus utility on-bill for tenant-meter-aligned measures up to the on-bill cap.

3 Results

3.1 Owner Net Present Value.

Table 2 reports 30-year owner NPV. At 5% (headline), all owner NPVs are negative under default $\kappa = 0.3$ —financing burden exceeds the owner's savings share without grant layering. Combo B produces the best owner NPV (−\$829K) because on-bill shifts \$300K debt service to the tenant meter; NYSERDA on-bill alone produces −\$784K but requires \$1,050K owner equity above the cap. The mechanism spread at any fixed κ is ≈\$417K, while varying κ over the realistic policy-achievable PBV range ($\kappa \in [0.3, 0.7]$) moves owner NPV by ≈\$354K within any mechanism—mechanism design and split-incentive resolution are therefore of comparable importance. At 7% discount the ordering is preserved but the on-bill advantage narrows.

Table 2. 30-year owner NPV by mechanism, default $\kappa = 0.3$.

Mechanism	Annual DS (\$)	NPV @ 3% (\$)	NPV @ 5% (\$)	NPV @ 7% (\$)
C-PACE (CT)	123,528	−1,360,247	−1,178,355	−1,028,150

CT LIME Loan	117,699	-1,412,371	-1,201,156	-1,032,478
NYSERDA On-Bill (capped)	0 (tenant)	-711,304	-784,364	-835,572
CT Green Bank (LIME+CEF)	112,967	-1,341,969	-1,142,184	-982,347
Combo A: C-PACE + CEF Bank	124,835	-1,330,993	-1,159,557	-1,016,553
Combo B: Green Bank + On-Bill	87,863	-968,488	-829,335	-716,397

3.2 Split-Incentive and Tenant Counterfactual.

Tenants under C-PACE or LIME capture \$619,817 in 30-year NPV at 5% (full 70% of gross savings unencumbered); under on-bill they capture only \$339,750 because the on-bill charge deducts from utility savings during the 15-year tenor. This comparison is conditional on project execution: at the calibrated C-PACE/LIME owner NPV of -\$1.18M without grant or non-energy-benefit layering, the realistic counterfactual may be no retrofit, in which case tenant NPV is zero. On-bill delivers a smaller-but-actual tenant benefit; C-PACE/LIME deliver a larger-but-conditional benefit.

3.3 Five-Criterion Scoring.

Table 3 reports the scoring matrix with rank-relative Owner NPV. C-PACE has broad cross-state availability but limited multifamily penetration: only 6.7% of Connecticut's 405 closed C-PACE deals are multifamily ([4], p. 291). On-bill-inclusive mechanisms tie for the lead under equal (3.40) and owner-focused (3.60) weighting; NYSERDA on-bill leads policy-focused (3.60 vs Combo B 3.35). C-PACE scores 3.00 under equal weighting, tied with green bank options but below both on-bill-inclusive mechanisms; the practitioner default does not lead under any scheme. See Fig. 1.

Table 3. Scoring matrix (1 = poor, 5 = excellent). Owner NPV scored rank-relative; for NYSERDA on-bill, the score reflects only the \$300K on-bill-financed portion, with the \$1.05M equity gap captured by Capital Adequacy = 1.

Mechanism	Cap. Adeq.	Split-Inc.	Owner NPV	Trans. Cost	Scale
C-PACE (CT)	4	2	2	3	4
CT LIME Loan	4	2	1	4	2
NYSERDA On-Bill (capped)	1	5	5	3	3
CT Green Bank (LIME+CEF)	5	2	3	3	2
Combo A: C-PACE + CEF Bank	5	2	3	2	3
Combo B: Green Bank + On-Bill	5	4	4	2	2

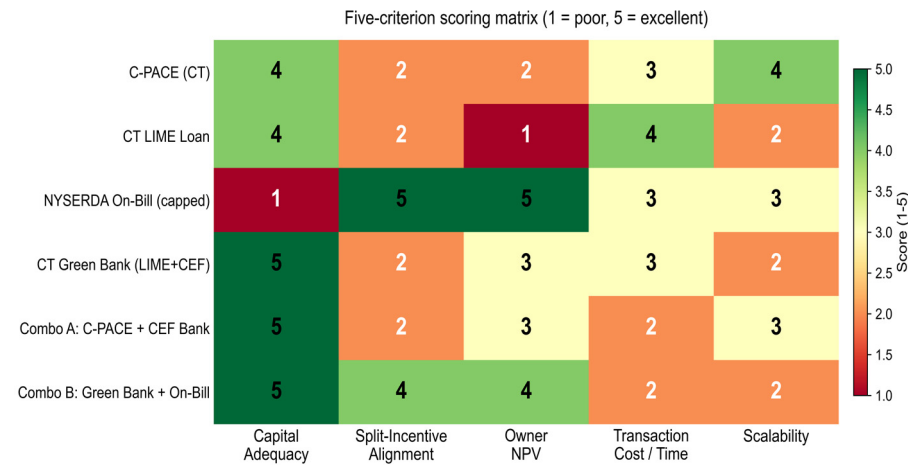


Fig. 1. Scoring heatmap; Owner NPV scored rank-relative within the comparison set.

4 Discussion

C-PACE faces two underappreciated feasibility constraints at the affordable-multifamily population: the FHA/HUD/CHFA exclusion in Connecticut is empirically binding (6.7% of 405 closed deals were multifamily, [4] p. 291); and the statutory $SIR > 1$ requirement may fail at typical retrofit parameters. SIR sensitivity: 0.51 at 25% savings (HUD GRRP minimum), 0.65 at 32% (baseline), 0.81 at 40%, 1.01 at 50% standalone; adding Investment Tax Credit (\$120K on $\approx$ \$400K solar PV) and Solar Home Renewable Energy Credit revenue (15-yr nominal $\approx$ \$180K) as Projected Associated Savings lifts each scenario by $\approx$ 0.13. $SIR > 1$ therefore requires either $\approx$ 50% savings standalone or $\approx$ 45% savings stacked with ITC and SHRECs—explaining why the 405 successful CT C-PACE deals typically include substantial solar PV.

Standalone NYSERDA on-bill's strong scoring deserves direct engagement: it is the policy-focused leader (3.60) and ties Combo B for the equal-weight lead (3.40), even though its \$300K cap leaves \$1,050K of owner equity to be sourced elsewhere—a binding constraint captured by '1' on capital adequacy. The honest reading: on-bill wins where that gap can be filled (state grants such as the NY HCR Climate Friendly Homes Fund at up to \$25,000/unit [6] p. 6; or federal tax credits) and combinations win where it cannot. Combo A (C-PACE + CEF Bank) does not lead under any weighting; its slightly higher debt service than C-PACE alone reflects a deliberate risk-allocation trade rather than a financing-cost reduction. Adding federal layering captured outside the headline model—30% ITC on solar PV ($\approx$ \$120K year-0) plus 15-year SHREC revenue ($\approx$ \$125K NPV at 5%)—shifts owner NPV by approximately \$245K under any primary mechanism; stacked with a \$25K/unit state grant, owner NPV moves comfortably positive.

5 Limitations and Conclusion

The comparison rests on a Connecticut-calibrated scenario with a NYSERDA on-bill cap; rankings may differ in single-state jurisdictions. Federal IRA layering, state grants, property-value uplift, and non-energy tenant benefits are excluded from the headline. Extension to Climate Zone 3 jurisdictions (e.g., Texas PACE, Florida SELF program), where cooling-dominated load profiles, lower utility costs, and different state policy environments prevail, would test the universality of the rankings. No subnational mechanism dominates across all five criteria: C-PACE leads on scalability but has limited multifamily penetration; on-bill leads on split-incentive alignment but is capacity-constrained; green bank packages lead on capital adequacy. Standalone NYSERDA on-bill leads policy-focused scoring where the \$1.05M equity gap above its cap can be filled externally; Combo B (Green Bank + On-Bill) beats the practitioner-favored C-PACE-plus-credit-enhancement combination on owner NPV by $\approx \$330\text{K}$ at 5% discount where it cannot. Mechanism choice should be informed by explicit weighting of the five criteria with attention to who bears the financing burden and to whether the realistic counterfactual is project execution or no retrofit at all.

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