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Financing "climate-proof" housing? The premises and pitfalls of PACE finance in Florida

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ABSTRACT

Amidst growing concerns about climate risks to the U.S. housing markets, strategies to physically retrofit homes are gaining attention—including within debates over how to resolve intersecting crises of housing re/insurability and affordability in highly exposed sites like Florida. We consider an important but under-studied example of this "climate-proofing" strategy unfolding today: Residential Property Assessed Clean Energy (PACE) finance. While PACE has historically financed decarbonization retrofits, it is increasingly being deployed to facilitate hurricane risk reduction in Florida. In this paper, we introduce PACE: its basic characteristics, evolving uses, and controversies. Exploring the Florida case, we examine two deeper but as yet under-examined financial tensions: PACE's intersections with other forms of property-linked finance (and potential systemic breakdowns) and rising affordability breakpoints as homeowners encounter its new debt amidst other growing and intersecting climate/climate response costs. These issues call for more transformative imaginaries of urban retrofitting and its resourcing.

KEYWORDS

Finance; housing; climate risk; retrofitting; Florida

Introduction

Threats to homes and housing markets are an increasingly important concern in U.S. climate change governance and pose a rising challenge for urban researchers and practitioners. How might already-arriving climate change impacts like more-frequent, more-severe floods or wildfires physically damage homes; devalue residential properties in highly exposed neighborhoods, cities, and states if capital and residents exit for less-risky locations; and otherwise disrupt and reshape the character of residential property markets? How can associated risks be managed, and in ways that do not exacerbate preexisting classed and racialized harms for frontline communities?

In this paper, we consider the last questions by taking up a rapidly growing but under-examined form of climate risk response, "climate-proofing" retrofits intended to reduce existing homes' physical damages from disasters or otherwise prepare them for a climate-changed future. These retrofitting interventions are taking differentiated forms in U.S. cities and regions, related to varying climate risks. These might include, for example, home hardening improvements like hurricane wind- or wildfire-resistant roofing; building elevation to reduce flood risk; or water-saving and energy efficiency measures against drought, elevated summer heat, and other intensified extreme weather. Here, we focus on how climate-proofing retrofits may be financed or otherwise resourced—and particularly on financial instruments which purportedly address barriers for lower-income homeowners facing intersecting crises of housing climate risk and affordability. Relatedly, we also consider linkages between climate proofing, financing, and financial risk, both for households and housing markets

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more broadly. Climate proofing advocates increasingly argue that, beyond reducing physical risks, measures also translate into financial risk reduction for homeowners—and, when taken in aggregate, for property markets and tax bases—by helping keep residential property insurance affordable for homeowners, thereby lessening the risk of larger-scale devaluation in highly exposed places.

The central climate-proofing financial instrument that we explore here is residential Property Assessed Clean Energy (PACE), particularly its recent rise in Florida as a tool for financing homes' hurricane hardening retrofits. Despite a growing demand for financing instruments aimed at addressing various climate challenges in existing building stocks and PACE's ongoing U.S. take-up and extension to new urban use cases, the instrument has attracted limited scholarly attention and analysis. This is a crucial absence. A form of value capture finance, PACE was created in the late 2000s as a variant of a familiar U.S. public financing instrument, the special district. It was first imagined as a tool for decarbonization retrofits, especially intended to serve lower-income homeowners historically excluded from private home improvement loans and to allow local governments to operate such retrofitting programs at low/no cost or risk to general funds. In the last 10 years, U.S. local governments have used PACE to finance billions of dollars of retrofits to homes and commercial properties, especially in California and Florida. In the process, they have expanded its uses to include a broader range of climate-proofing and risk reduction applications, most recently hurricane wind risk in Florida.

Crucially, PACE's growing application to Florida residential hurricane risk mitigation increasingly positions it (and the physical climate-proofing interventions it enables) as a new tool to address the state's growing crisis of insurance and reinsurance market stability under climate change—i.e., via materially de-risking the multi-trillion-dollar volume of property catastrophe exposure currently held by Florida's residential property re/insurance system. Such a shoring-up is argued to be necessary for re/insurers to continue to finance housing climate risks at affordable costs. We expand on existing scholarship which focuses on the use of insurance-linked securitization to stabilize insurers in high-risk regions including Florida (Johnson, 2014, 2015; Taylor, 2020). A broadened view is timely. Hurricane Ian's deadly and destructive landfall in southwest Florida in September 2022 represents the latest in a string of major U.S. disasters with a climate change signal. This sequence has raised growing concern about the durability of re/insurance-led housing risk governance and adaptation strategies, in and beyond Florida (e.g., Flavelle, 2022; Sherfinski & Baptista, 2023). As re/insurers decline to finance property risks at pricepoints affordable for frontline residents, the prospect of (un) insurability—and housing market devaluation—looms ever larger and is prompting a search for new ways to resource risk mitigation efforts.

We consider both PACE's promises and its pitfalls in facing this challenge, including thornier questions around affordability and systemic financial risk. The case for PACE as a low-cost, low-risk financing tool centrally rests on the argument that upfront costs needed for retrofits can pay themselves back to homeowners via new property-linked value streams over time—first, energy savings; increasingly, insurance costs avoided. The instrument takes the form of a primary lien on homes that must be repaid as an addition to existing property tax bills for periods ranging from a few years to a few decades. Advocates argue that this parallel stream of income/avoided costs offsets the financial burden of new (quasi-)debt obligations, which otherwise might exacerbate affordability issues facing lower-income homeowners—compounding cost burdens that might result in property tax defaults, local government foreclosures in the case of protracted nonpayment, or other compelled home sales and displacement. Meanwhile, advantages marketed to local governments include the ability to outsource PACE program financing and operation to private partners, now a frequent practice dominated nationally by a few large corporations. As we will discuss, PACE's highly uneven U.S. expansion to date has been shaped by ongoing regulatory challenges and questions on these win–win premises. Notably, consumer protection advocates have alleged that some programs, including in Florida communities, are badly under-regulated, enabling significant abuses and predatory lending.

We discuss these more immediate consumer protection challenges after introducing PACE in more detail in the following sections. After reflecting on Florida's PACE experience to date, we then focus

especially on two more structural financial tensions which we suggest particularly need attention from researchers and practitioners—including in their potential significance for other climate-proofing and financing experiences. The first relates to the interdependent, nested position of PACE lines in relation to other forms of property-linked finance. A collapse in any one of the interlocking financial support systems that underpin and enable Florida's housing market (i.e., property re/insurance, but also mortgage and municipal finance) may threaten those indebted through PACE, in ways so far under-examined. Second, related questions emerge about un/affordability breakpoints for homeowners as PACE repayment obligations join insurance premiums, mortgage debt, further property taxes, and other property costs likely to rise due to climate change. What risks and harms (and to whom) may manifest if promised cost reductions due to climate-proofing fail to materialize or simply cannot keep pace with these other growing, stacking expenses?

Methodologically, this paper's discussion builds on a decade of parallel research projects at the intersection of housing, finance, and climate change governance, within Florida and more broadly. This includes a corpus of extensive elite stakeholder interviews, policy analysis, and forensic financial analysis in Florida real estate and climate adaptation contexts, as well as on the historical PACE rollout and re/insurance networks. For this analysis, we complemented existing knowledge with an extensive review of publicly available technical reports, in-depth investigative reporting, and other media and market data regarding PACE. The choice to focus on Florida has been motivated both by this existing knowledge base and by the state's unique visibility in contemporary discussions about real estate climate risk, devaluation, and insurability. Some features of the Florida case are exceptional in both the U.S. and international contexts, including the sheer concentration of real estate property value exposed to climate risk and the state's reliance on access to global property catastrophe reinsurance markets to finance risks (see Taylor, 2020). However, challenges related to climate-proofing, financing, and re/insurance have clear resonance for other U.S. cities and states with acute climate risk exposures (and beyond, though we focus on the U.S. case here); for example, California and other Western states facing heightened wildfire risks and similar insurability and affordability dilemmas.

Literature review

This paper draws together several areas of scholarship on climate change as a threat to property values, re/insurance as an imagined solution to that devaluation threat and as a source of crises under climate change, and on urban climate retrofitting and financing, broadly construed.

First, a fast-evolving scholarship now analyzes and problematizes climate change as a locus of property devaluation, particularly as this perceived threat becomes a more prominent and mainstream concern incorporated within property market decision-making processes. For example, Gourevitch et al. (2023) find U.S. residential property at risk of flooding to be overvalued by between $121 and $237 billion. Growing research examines the current and potential extent of climate-related asset devaluation, including questions of whether that devaluation will be short-term or durable (Clayton et al., 2021; see also Keys & Mulder, 2020; McAlpine & Porter, 2018; Thompson et al., 2023). Related are considerations of the mechanisms that may trigger such processes, including but not limited to first-hand experiences of damages, shifting market actor risk awareness and sentiment, rising insurance premiums, changing patterns of lending and asset investment, unequal patterns of infrastructure provision, reallocations of public investment, and other asset price-shaping variables (Clayton et al., 2021; Keenan & Bradt, 2020; Palm & Bolsen, 2020; Taylor, 2020; Taylor & Aalbers, 2022; Taylor & Erasmus, 2022).

Meanwhile, scholars are increasingly considering emerging geographies of both devaluation and potential revaluation across housing markets under climate change (e.g., Knuth, 2019; Taylor & Aalbers, 2022). These include speculative property market actor-driven strategies which exploit emerging geographies of risk and devaluation within and beyond particular urban neighborhoods, as relatively less exposed sites become targets for new forms of "climate gentrification" and inequitable patterns of restructuring (e.g., Keenan et al., 2018; Taylor & Aalbers, 2022; Thompson et al., 2023). For

example, Taylor and Aalbers (2022) demonstrate how a range of property-finance stakeholders, from local land speculators to transnational reinsurance companies, craft and act on perceptions of (future) risk in ways that speculatively produce, rather than solely respond to, geographies of housing devaluation and revaluation in South Florida.

Second, this paper contributes to growing discussions on climate change and insurance. As noted above, to date a leading imagined strategy for offsetting the prospect of climate-induced property value destabilization comes by way of calls to bolster existing residential property insurance and reinsurance (that is, insurance for insurers) systems. Well-established re/insurance regimes have long assumed primary responsibility for financing housing-linked disaster risks within the context of the U.S. housing finance system, essentially cleaving off major concern about climate risk from the business of financing real estate (Kunreuther, 1996; Taylor, 2020). Homeowners, city hazard managers, resilience planners, mortgage lenders, and other transnational financial market institutions collectively buy into the promise to pay afforded by re/insurers, thereby sustaining residential building, buying, and selling in highly climate change-exposed regions like coastal Florida and Louisiana or wildfire-prone geographies in the U.S. West.

Contributions such as Collier and Cox (2021), Johnson (2014, 2015), Elliott (2018, 2021) and Taylor (2020) explore growing climate-related strains to this risk-financing system in the U.S. context, and the deeper tensions and challenges that shape responses to the new threat of climate change. Much of the research focuses on private re/insurers, though Elliott (2018, 2021) has unpacked the U.S.'s premier public(-private) scheme for flood risk insurance, the National Flood Insurance Program (NFIP). Johnson (2014, 2015) and Taylor (2020) have advanced understanding of insurance-linked securitization (ILS) as a financial(ized) pathway for addressing the crisis of private re/insurance, on top of other strategies like reevaluating and remapping flood risk and undertaking more managed de/revaluation of properties located in high-risk zones (Elliott, 2018, 2021). Among core value propositions and uses, ILS seeks to extend the underwriting capacity of re/insurers by transforming risk premiums into an asset class for non-insurer investors like pension funds. By further capitalizing the re/insurance system, ILS is therefore premised as a means to enable sustained underwriting in troublesome "peak peril" property insurance markets—namely Florida and East Coast hurricane wind risk and, more recently, wildfire risk in Western U.S. states like California.

Third, this paper seeks to expand and broaden existing scholarly discussions of urban climate retrofitting, particularly to older existing homes: legacy residential assets frequently inhabited by lower-income and otherwise marginalized households in the United States, both homeowners and renters (e.g., Bigger & Knuth, 2023; Knuth, 2019). More critical social scientific discussions of housing retrofitting for climate change remain limited. However, this initial work points to a growing disjuncture between newly-built housing and legacy residential building stock in many cities. Older structures can inherit increasingly obsolescent building technologies, systems, and standards compared with newer homes constructed (in some, though not all cases) under improved building codes. Disparities also arise due to structures' physical breakdown over time, joined with varying investments in maintenance and repair. These embedded legacies acquire new significance under climate change; as, for example, energy in/efficient homes become a decarbonization challenge (Knuth, 2019), or as assets built before more recent building code improvements face growing physical risk exposures.

Existing work on housing and climate retrofitting has focused predominantly on decarbonization applications (Knuth, 2019; Thoyre, 2021), rather than the emerging risk-centric applications and issues taken up here. A similar skew toward decarbonization is presented within (limited) social scientific scholarship on PACE (Knuth, 2019; see also Rose & Wei, 2020). An important exception is Elliott's (2018, 2021) work on housing retrofitting undertaken in response to changing NFIP rules, rising costs, and cost mitigation options, particularly building elevation as a climate-proofing strategy to mitigate flood risk and associated insurance costs. Elliott also critically considers financing and affordability issues related to such proposed strategies. More broadly, discussions of climate-proofing retrofits join fast-growing discussions of urban repair and its financing under climate change. Some of this work takes up repair as a progressive vision for rebuilding cities for a climate-changed future (e.g.,

Bigger & Knuth, 2023). Other research warns of new exploitation pathways and forms of disaster capitalism (e.g., Bigger & Millington, 2020; Ponder, 2021).

Finally, this paper contributes to broader debates over the politics of urban climate finance, as crucial questions emerge over how climate-proofing interventions should be imagined, organized, and funded. In its reliance on public-private financing partnerships and value capture mechanisms—i.e., infrastructural investments intended to be "self-financing" via generating and capturing revenue—PACE finance draws on a familiar neoliberal urban toolkit. Though value capture finance now assumes varying forms and politics in cities worldwide (e.g., Dunning & Lord, 2020; Vejchodská et al., 2023), U.S. scholars have observed downsides to risks in this privatization and individuation of urban finance (e.g., Ashton et al., 2012) that climate-proofing discussions must consider. Following these debates, our engagement focuses on two key lines of discussion: First, we question how climate-proofing interventions and financing mechanisms like PACE that center on piecemeal, voluntary uptake by individual homeowners may clash with more collective, large-scale climate-proofing and investment needs increasingly delineated by scholarship on urban and regional climate adaptation planning (e.g., Anguelovski et al., 2016; Mach & Siders, 2021; Shi & Moser, 2021; Shi & Varuzzo, 2020). Second, we consider a growing argument advanced by both housing movements and climate-debt justice activism (e.g., Bigger & Knuth, 2023; Táíwò, 2022)—that private debt financing for climate-proofing, even in ostensibly below-market rate forms like PACE, may be inherently risky and extractive for historically marginalized communities (many of whom are also excluded by housing interventions which structurally favor single-family homeowners—see Kear et al., 2023). Related scholarship calls for more transformative imaginaries of climate adaptation, including progressive funding/resourcing forms like grants and other direct public investments at scale.

PACE: A primer

In this section, we introduce PACE finance in three parts, presenting a brief overview of the instrument's origins, basic features, and expanding uses; reflecting on how the legal and financial case for PACE has been made; and summarizing key concerns raised about the instrument—particularly consumer protection challenges. This introduction sets the stage for Section 4's more embedded analysis of PACE's rollout in Florida.

Origins and key features

PACE was created in California in the late 2000s, as the City of Berkeley sought new financing options to advance decarbonization commitments made in its 2006 climate plan (Fuller et al., 2009). PACE was originally intended as a tool for accelerating investment in energy efficiency retrofits and rooftop solar technologies, particularly for lower-income homeowners excluded from conventional financing options like home improvement loans. PACE's proponents argued that they could get cash-strapped homeowners more affordable financing for climate-related improvements than private alternatives. Simultaneously, they contended that PACE gives local governments a tool for acting on climate change that "provides virtually no risk to the local government's general fund" (Fuller et al., 2009, p. 3; Qiu & Durkay, 2016).

PACE financing generally covers the entire cost of a property improvement or repair and typically requires no upfront payment by property owners. PACE is used both by commercial property owners (in a slightly different instrument known as Commercial PACE, or C-PACE) and homeowners, via residential PACE. However, only three U.S. states currently allow these home uses: California, Florida, and Missouri. The U.S.'s cumulative residential PACE lending was $7.7 billion as of December 2021, for about 323,000 home retrofits (PACENation, 2022). Repayment periods for homeowners vary, though they are generally longer than the standard 5–7 years of conventional home improvement or utility loans (Fuller et al., 2009). Qiu and Durkay (2016) suggest 5–20 years, Grind (2017), 5–25 years, and Carollo (2021), 10–20 years.

Loan amounts similarly vary: Grind (2017) finds that loans range from about $5,000 to over $100,000 but average around $25,000 with a 6–9% interest rate. Fuller et al. (2009) and Burns (2021) found similar numbers, though Burns suggests that interest rates for new PACE assessments are more variable and sometimes very high, from 4% to 12% (We return to this point later).

PACE's financing model directly adapts the special district form, a financing tool long familiar to U.S. cities and local governments. Berkeley's inaugural program was set up as a Mello-Roos special tax district, for example. Other PACE programs in and beyond California have adapted special assessment district forms for this new climate-facing purpose. For example, Florida operates through special districts, interlocal districts, or municipal districts. While U.S. state government powers differ slightly, most already have some form of special assessment district on the books. However, states must specifically authorize an extension of this form to PACE before county and city governments can establish or join a district. Thirty-eight states have now authorized PACE in some form (PACENation, 2022). State legislatures must agree that PACE meets the traditional special assessment criteria in that it is "for a public purpose and [provides] benefits both to the public at large and to the assessed property" (Sichtermann, 2011, p. 291).

States define what kinds of improvements count as a valid public purpose; for PACE, they are typically framed in terms of both varying climate benefits and green jobs creation. Property owners who pay assessments are also legally required to receive specific additional benefits. PACE proponents have argued that the instrument provides multiple lines of climate-related cost savings, income potential, and land value-added. These climate-facing purposes and lines of value increasingly encompass retrofits that we might classify within broader forms of climate-proofing and risk reduction. For example, California PACE districts now may finance water-saving retrofits—an important climate-related improvement given the state's increasingly severe droughts—or non-climate purposes in the form of seismic retrofits (Rose & Wei, 2020). As we discuss below, hurricane wind risk reduction in Florida is a newer and fast-growing use.

Constructing PACE's legal-financial case

In legalizing PACE for new places and retrofitting purposes, state-level authorizers must grapple with the unusually privatized form of the instrument relative to traditional special assessment improvements like roads, sewers, or parks. Historically, networked infrastructure and local public facilities have benefitted from private properties. However, unlike PACE's climate retrofits, they were not directly installed *within* those properties (though there is precedent for building-level special assessments for seismic retrofits—see Rose & Wei, 2020). As such, some states have had to amend special assessment legislation to authorize PACE projects on private property. In addition, typically every property owner within a special district is assumed to receive the benefits of collective infrastructure, and are required to pay for them collectively. Instead, PACE takes on a more privatized, voluntaristic form: individual property owners within a PACE district opt in (or not) to undertake retrofits and qualify for attached financing.

To secure the necessary policymaker buy-in needed to authorize PACE, its proponents have sought to leverage multiple kinds of financial power. First, they looked to local governments' inherited instruments and practices. Rather than loans per se, PACE takes the form of a local government-administered lien on a property, for a set time period. Normally, property owners gradually repay PACE liens annually or semiannually on their property tax bill, like any other special assessment or special tax. Local governments collect associated taxes and, in the worst case, will foreclose on properties if owners fail to pay taxes for too long. Crucially, a PACE lien usually takes senior status, like other property taxes and assessments: i.e., in a foreclosure sale, the PACE obligation is paid off before mortgages and any other property-secured debt. Proponents argue that PACE's ability to secure loans with property, senior lien status, and assumed support from governments all lower its assumed risks and therefore interest rates charged to homeowners.

Second, PACE's creators pointed to untapped value-creation potential in climate-related retrofits, arguing that PACE loan design can be tied to related value streams. This argument has been most fully developed for energy efficiency and rooftop solar retrofits. These decarbonization interventions have long been argued to pay for themselves, and increasingly also to convey a green premium in added property value (Knuth, 2016, 2019; Thoyre, 2021). Proponents have argued that streams of energy savings would materialize as lien payments began, and therefore result in no net cost to property owners (Fuller et al., 2009; Qiu & Durkay, 2016). Some states, like Missouri, formally require that energy savings from each PACE project are at least equal to its costs. Critics argue that this state's rule has not been followed in practice, as energy audits are not required, and private lenders and contractors are generally under-regulated (Kohler & Coryne, 2021). Value added for newer risk-facing retrofits is typically framed in the form of future costs avoided by governments and homeowners, i.e., mitigating the expense of future damages and clean-up/recovery costs. However, these value cases have been less tested in practice.

Third, private financial players and investors have become central to PACE's model. In Florida, PACE districts are run as distinct units of local government, which cities and counties can opt into. These PACE districts raise capital to make loans via selling bonds backed by streams of lien repayment, which are often packaged into asset-backed securities representing aggregated streams of lien repayment from many property owners. Grind (2017) discusses an exemplary residential PACE bond aggregating more than 10,000 loans. Like other forms of value capture, finance, bond activities and repayment streams are held separate from local governments' other taxing and spending as off-balance sheet conduit finance. Governments are meant to recoup any administrative expenses for PACE programs through interest charges. Advocates point to this financial independence in arguing that PACE presents no risk to general funds. For example, Qiu and Durkay (2016) argue, "[a]s long as the bond issuance is designed properly, financing a program will not impact state or local budgets." Grind (2017) notes that bonds created from residential PACE loans have been highly rated and attractive to Wall Street, with over $2.7 billion in cumulative securitization at that time. She suggests that PACE bonds have been especially popular with mutual funds and insurance companies, who "like the bonds' relatively high payouts, environmentally friendly reputation and lofty credit ratings."

Governments typically now heavily rely on private administrators to run their residential PACE programs and float bonds (Burns, 2021). This private PACE administration and lending has been dominated by a few big players operating U.S.-wide: Renovate America (the largest before it filed for bankruptcy in December 2020), Ygrene, and Renew Financial. Each had issued hundreds of millions of dollars in securitized loans as of 2017, almost $2 billion in Renovate America's case. These companies further outsource lending to smaller private (sub)contractors, who both sell loans and perform retrofits (Carollo, 2021)—Grind (2017) argues that this means that "[p]lumbers and repairmen essentially function as loan brokers but have scant training and oversight. They often pitch PACE loans to land contracting jobs and earn referral fees from lenders."

We provide an overview of a typical PACE arrangement in Figure 1, pinpointing key actors and relationships between them. The dotted boxes and arrows refer to important but less direct stakeholders in the transaction structure, such as local governments, (secondary) capital market investors, mortgage lenders, and property insurers. We return to questions about the roles and interface between these direct and indirect stakeholders more in subsequent sections.

Critiques and challenges

PACE programs have been subject to substantial critique, ranging from regulatory concerns over consumer rights and predatory lending practices to more systemic anxieties about the relationship between PACE and the U.S. housing finance system. Ongoing justice and financial risk concerns about PACE have been raised by consumer advocates and legal aid groups across all three states in which it now operates (e.g., Burns, 2021; Carollo, 2021; Kohler & Coryne, 2021). All three big PACE lenders have seen significant lawsuits—Renovate America alone was facing 50 when it filed for bankruptcy

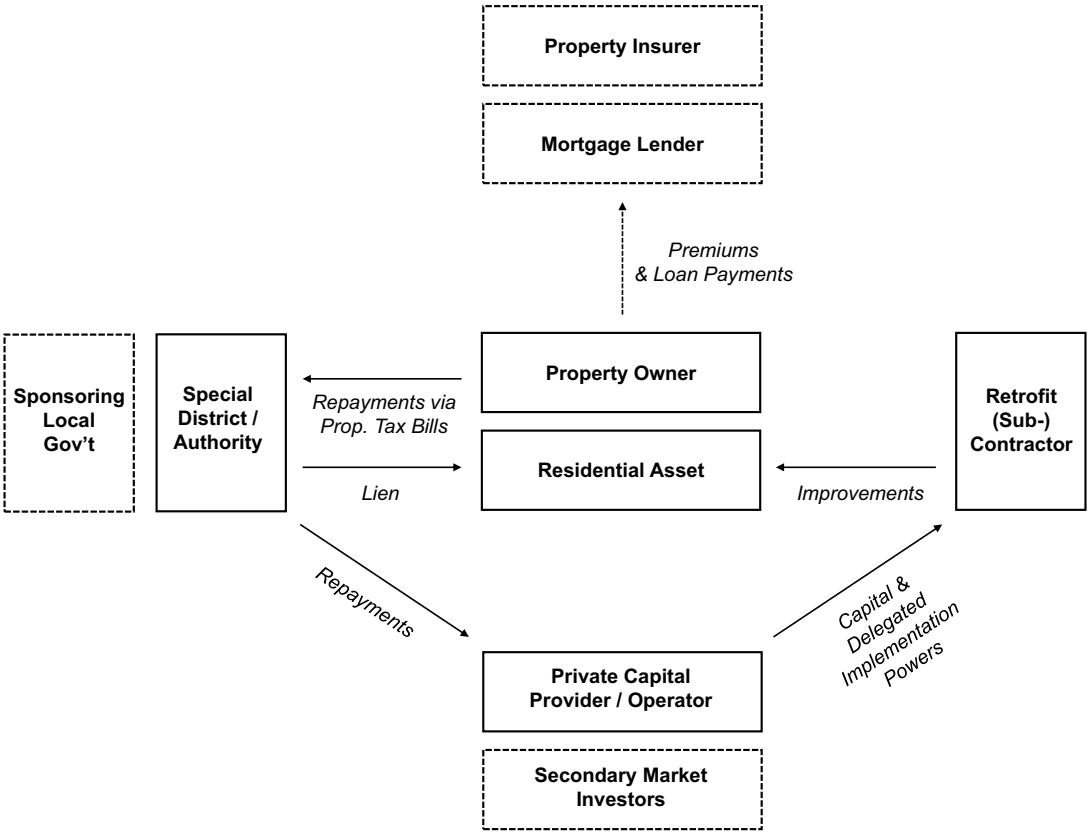

Figure 1. A typical residential PACE program structure. Source: Authors.

(Grind, 2017). Critics have raised concerns regarding poorly trained and unscrupulous contractors, charging that they have trapped cost-burdened, elderly and non-English-speaking homeowners into long-term debt products that they do not understand. At least eight U.S. counties have ended PACE programs due to consumer protection concerns (Burns, 2021).

Most PACE proponents argue that these consumer concerns remain marginal bad experiences rather than structural flaws, and similarly maintain that actual defaults and resulting tax foreclosures have remained low. Therefore, they argue, these loan products remain low-risk for most homeowners, local governments, and investors. Federal regulation (e.g., from the U.S. Consumer Financial Protection Bureau) of PACE programs has been scant. However, tighter regulatory scrutiny is emerging at lower scales of government, and several states have revisited PACE legislation—including a major overhaul in California.

However, the prospect of more systemic failure has always haunted PACE. Vocal critics like Grind (2017) in the *Wall Street Journal* remain on the watch for signals of larger-scale homeowner defaults on property taxes due to added assessment costs and resulting tax foreclosures. More significant has been ongoing regulatory resistance by the Federal Housing Finance Agency (FHFA), Fannie Mae and Freddie Mac's conservator since the Global Financial Crisis. Amidst the foreclosure crisis in 2010, the FHFA ruled that neither of these government-sponsored enterprises (GSEs) could purchase mortgages with PACE liens, chiefly because these liens would typically be paid off before federally backed mortgages in a foreclosure. This ongoing prohibition has killed many states' residential PACE programs and created enduring uncertainty (Knuth, 2019). For example, existing PACE liens are supposed to stay with properties if homeowners move, but FHFA prohibitions often force homeowners to pay them off in a sale so that properties can be re-mortgaged (e.g., Kohler & Coryne, 2021).

At a more granular level, Kohler and Coryne (2021) begin to point to other structural faults, which are classed and racialized. They note that a typical PACE lien amount can be a far more significant proportional burden on lower valued properties; ironically, PACE works much better for richer homeowners who already had ample access to other forms of home improvement finance. Crucially, these authors also note that programs hit differently in cities and neighborhoods seeing broad-based decline: again, new PACE-generated streams of value/value-added may be swamped by more profound devaluation trends. Collectively, these critiques point to several potential ways in which both individual consumer concerns and broader property market crises can overwhelm the good intentions of PACE interventions. In the following section, we take this insight up in further detail through a critical reflection on the rollout of PACE in Florida.

PACE and Florida climate-proofing: Framings and tensions

In this section, we discuss the extension of PACE finance to hurricane risk reduction in Florida as an important test case for the instrument as a climate-proofing tool. We dig further into this rollout, which has tended to focus on hurricane wind risk reduction measures, particularly in South Florida municipal and county jurisdictions. We consider important ways in which PACE financing is enabling climate-proofing in the state, after past disappointments using other mechanisms. Picking up on the last point from the previous section, we then reflect on emerging structural financial tensions around PACE, including both under-examined systemic financial interdependencies (and possibilities for breakdown) and potential affordability breakpoints for homeowners—particularly though not exclusively lower-income Florida residents.

PACE comes to Florida

In 2010, the State of Florida passed legislation authorizing local governments to use PACE to finance climate-related retrofits within existing homes and commercial buildings. By 2021–2022, Florida had at least $1.5 billion cumulatively in PACE-funded projects, overwhelmingly invested in the residential side (Carollo, 2021; Home Run Financing, 2022; Renew Financial, 2022). Ygrene and Renew Financial make up most of Florida's residential PACE market, alongside some smaller players (e.g., Home Run Financing, 2022). Both are quickly growing their Florida portfolios. Renew Financial (2022) currently has over $430 million in residential PACE loans in Florida. Ygrene has even more, nearly doubling from 2018 to 2019 to $848 million, and exceeding $1 billion by 2020—although this figure may also include some C-PACE (Carollo, 2021).

Although Florida homeowners continue to pursue PACE applications like energy efficiency, hurricane hardening retrofits now account for the largest share of PACE financing in the state. They represent 71% of Ygrene's PACE investments in Florida, totaling over $525 million (Oliphant et al., 2020). Similarly, more than half of Renew Financial's (2022) $430 million in investments were on hardening projects—namely, storm shutters for windows, high impact windows and doors, and wind-resistant roofing. Although these represent substantial volumes of investment, PACE finance flows only to jurisdictions (i.e., county and municipal governments) that have opted in to a program. These flows are largely (and asymmetrically) located in South Florida. Oliphant et al. (2020) note that almost all ($765 million in 2019) of Ygrene's investments were in South Florida, with Broward, Miami-Dade, and Palm Beach Counties leading the way. Central Florida, including the Greater Tampa Bay and Orlando areas, had $81 million of Ygrene investment, while North Florida, home to Jacksonville, only had $2 million.

In principle, the focus on financing hurricane wind risk reduction is a logical innovation for PACE in Florida, given the state's unique exposure to hurricanes, among other physical climate risks. In the past 3 decades, a range of catastrophic storms—including Category 5-storms Andrew (1992) to Ian (2022)—have led to significant loss of life and more than $300 billion in estimated normalized damages (Beven et al., 2019; Bucci et al., 2023; Weinkle et al., 2018), corresponding to damage to

hundreds of thousands of homes, businesses, and pieces of public infrastructure throughout the state. These losses have prompted significant analysis and reforms related to insurance, building regulations, and other policy solutions that can help climate-proof (physically mitigate) wind risks for new and legacy assets (e.g., Done et al., 2018; Peacock, 2003; Weinkle, 2015), alongside broader questions of urban and environmental planning (e.g., Butler et al., 2022; Catlin, 1997).

Within this context, the hurricane hardening approaches financed by PACE have demonstrable potential to substantially reduce the state's residential risk exposure. For example, an actuarial analysis conducted on behalf of the Florida Office of Insurance Regulation found that "if every home across the state were hardened to a construction standard that exceeded the most current building code, . . . the insured average losses per year would reduce by over 70%" (Young et al., 2010, p. 2). Indeed, as PACE increasingly becomes a hurricane-focused program, its proposed value benefits to homeowners are also being recast: proponents now prominently advance retrofits' ability to avoid homeowner costs due to storm damages or reduced insurance premiums (Rose & Wei, 2020; Woodruff et al., 2020). Oliphant et al. (2020) note that Florida mandates insurance companies to offer premium discounts to policyholders who implement home improvements that reduce disaster risk. Proponents are also beginning to model the potential economic benefits to the broader public (Oliphant et al., 2020; Rose & Wei, 2020). Oliphant et al. suggest that Ygrene's PACE risk reduction investments in Florida to date may have reduced insurance premiums by $1.26 billion and avoided $970 million in disaster losses and $250 million in disaster displacement costs.

Climate-proofing experiments for legacy assets raise important questions about PACE's future. Research shows that improvements to the Florida Building Code have substantially improved the physical resilience of newer-built homes to wind risks (Done et al., 2018). However, in contrast to efforts focused on new-build housing, past hurricane hardening initiatives targeting legacy assets have seen important disappointments in practice. Attempting to stimulate the take-up of hardening measures, the State of Florida introduced a wind mitigation credit over 20 years ago—the scheme noted above by Oliphant et al. (2020), which discounts policyholder premiums for those who implement hurricane hardening improvements. Like PACE, this legacy climate-proofing mechanism aimed to simultaneously reduce residential risks, save homeowners money, and reinforce stable underwriting conditions for re/insurers. However, Young et al. (2010) note that only a fraction of homeowners who conducted risk-reduction inspections under this initiative ultimately implemented measures. Moreover, in cases where retrofits were undertaken, and consumers were able to claim a mitigation credit from their insurer, they argue that these risk reduction benefits were not always valued by reinsurers who assume risks from the primary insurer. In other words, Florida insurers had to sell consumer policies at a discount but purchase reinsurance at the pre-improvement rate—ostensibly undermining rather than reinforcing the industry's financial stability.

Property-financial interdependencies and breakdowns

Past shortcomings in Florida climate-proofing campaigns point to significant breakdowns between physical mitigation and insurance-based risk finance—that is, between homeowners making retrofits, and reinsurers and risk capital markets underwriting risks. PACE proponents cannot ultimately ensure that climate-proofing measures yield benefits like greater insurability or insurance cost reductions, given the many contingencies now reshaping Florida re/insurance and property markets (see, e.g., Evans, 2023; Flavelle, 2022). This slippage points to a need to more broadly consider whether financial interdependencies, and their brittleness, might similarly undermine PACE's value propositions and longer-term viability.

Taking on the first, it is important to examine how PACE finance joins the many other forms of finance linked to residential assets in Florida, including mortgage payments, insurance premiums, property taxes, and related public service costs. While these relations hold true for most U.S. communities, they are acutely significant in Florida given the state's exceptional physical climate risks, the outsized role of an internationalized real estate sector

in the state's economy, and the absence of a statewide income tax—and therefore governments' higher dependence on property taxation and real estate market stability to sustain their fiscal capacity (Cox, 2022; Taylor, 2020). In the context of climate-induced disruptions, underacknowledged interconnections between varying types of property-linked finance may lead to cascading breakdowns, with significant costs for frontline borrowers and communities. For example, mortgage lenders and their investors require homeowners to maintain adequate insurance as a condition of borrowing (Kunreuther, 1996). Absent available and affordable coverages, borrowers may not be able to access mortgage finance or sustain repayments. Relatedly, municipal bond market investors, and the rating agencies that determine the cost of credit to municipal borrowers, look to local property tax stability as a key indicator of potential borrower credit risk (Cox, 2022; Shi & Varuzzo, 2020). Property taxes, in turn, depend on stable real estate values. And so forth.

These interdependent systems of residential property finance threaten to pull apart under rising climate risks. Temporal mismatches between the investment horizons of various property-finance stakeholders are central to this tension. For example, residential insurance policies have a 1-year term, while the reinsurance protections that back them typically have only 3-year terms. This short-term commitment allows re/insurers to continually reprice risks and renegotiate policies, sometimes at profoundly high rates year-over-year (Taylor, 2020). In 2023, annual residential premiums were expected to increase roughly 40% in Florida—a substantial cost, given that the state's average residential policy premium of $4,231 is already three times the U.S. average (Paul, 2023). Rates are often higher still in the most risk-exposed areas. For homeowners locked into a conventional 30-year mortgage, this time-cost mismatch poses a serious financial risk. More generally, transnational property-finance actors have varying levels of capacity to control their financial exposure to highly exposed places or to exit them wholesale. In contrast, residents often have significant financial and non-financial investment in communities—and substantially fewer resources to divest.

PACE liens entangle properties in a web of financial arrangements tied to the long-term physical durability of homes, and the sustained "business as usual" appreciation of U.S. property value over time—indeed, climate-proofing's proposition is that physical retrofits can enable and bolster these conditions. Like 30-year mortgages, this underlying stability is particularly important for longer-term PACE contracts (e.g., 20–25 years). What are the consequences, however, if anticipated streams of lien repayments are undermined by more systemic near-term collapses of market-enabling institutions, such as a (further) withdrawal of insurers from coastal Florida? What if, in turn, "underwater" homeowners walk away from properties, leading to mortgage default? Far from hypothetical, these questions are increasingly relevant in the Florida context. In 2022, several Florida insurers were declared insolvent, hundreds of thousands of policies were dropped by private insurers and taken up by the state's insurer of last resort, and most policyholders saw substantial premium increases (Girod, 2023; Harris, 2023; Paul, 2023). Moreover, several insurers failed to obtain a sufficient rating of financial stability, raising questions about their policyholders' compliance with mortgage GSE requirements (Gallin, 2022)—in turn prompting the State of Florida to offer an additional $2 billion state-backed reinsurance fund to assuage lenders (Sheehan, 2022).

These tensions raise crucial questions about the extent to which climate-proofing, and PACE as a particular mechanism for it, ultimately mitigates (or worsens) financial vulnerabilities for frontline residents and communities. Institutional investors currently holding billions of dollars in PACE securities have (for now) backed this bet. Local governments may not bear direct costs if PACE bonds fail, but large-scale program and bond failures will at best leave their existing fiscal and credit rating troubles unimproved, and at worst actively impair them. For homeowners, PACE liens stand to join mortgage debt as a vector of foreclosure and loss of homes—they may not carry such property-secured debt with them, but that may be small consolation.

Emerging affordability breakpoints

A more immediate way of assessing tensions for homeowners relates to affordability breakpoints, as PACE costs stack atop rising property insurance premiums and other expenses. Here, the most cost-burdened homeowners may paradoxically experience PACE and other forms of intended risk protection as converging and rising financial risks, in the form of escalating housing costs, debt burdens, and overall affordability pains. Florida consumer advocates and regulators have separately flagged PACE liens and rising insurance costs as threats to homeowners. Similarly, over and above PACE programs, local governments face growing pressure to marshal resources to fund climate adaptation measures or risk bond market downgrading—and in Florida, these costs are largely funded through homeowners' property tax bills (Cox, 2022, 2023). Improved financial security theoretically afforded by new protections is never guaranteed and may exceed the means of cost-burdened homeowners even if it could be.

More sustained scholarly attention is required to unpack how these affordability breakpoints may materialize on the ground. Exemplifying these emerging areas of research, Taylor and Aalbers (2022) have emphasized the need to consider the intersecting relationships between housing, finance and climate risk along multiple criteria. They draw attention to homeowner demographics and asset characteristics, especially existing housing cost burdens and exposure to variable climate-related costs like rising insurance premiums and property taxes. Recent homeowners' insurance cost data underscore the magnitude of this additional risk-related cost variable for South Florida residents: In 2022, the average homeowners insurance premium (*exclusive* of flood insurance, also rising in cost) was $5,391 in Miami Dade County; $5,164 in Broward County; $5,247 in Palm Beach County; and $7,162 in Monroe County, as examples (Florida Office of Insurance Regulation, 2023). To underscore this point, Taylor and Aalbers (2022) map the geography of cost-burdened households against insurance rate data across Miami Dade County zip codes. They find that this geography partially intersects with histories of racialized housing injustice and the sluggish recovery from the foreclosure crisis of the 2000s (see Cox, 2023; Grove et al., 2020).

Forward-looking identification of PACE's potential affordability breakpoints—and challenges for climate-proofing in the Florida context more generally—also requires consideration of the varying physical risk exposure of homes, the extent to which retrofits to individual residential properties can meaningfully lessen those risks, and the costs that homeowners might accrue and avoid in doing so. As discussed above, hurricane hardening improvements like improved roofing have been found to be substantially effective in lessening property damage due to high-speed winds. However, flood risk mitigation may require much more capital-intensive improvements. Some, like building elevation, may be effectively implemented at the individual asset level in some instances. Other measures may require larger-scale investments and interventions, like water management infrastructure or wholesale asset removal and retreat. Complicating matters, but crucial for understanding the cost-benefits of action, there are efficiency and equity trade-offs between smaller- and larger-scale measures and strategies, and their combined use. Relatedly, opportunities for meaningful climate-proofing—and varying prospects for insurance cost savings via that retrofitting—will vary greatly by residential properties' age and construction standard. In Florida, legacy residential assets built before Hurricane Andrew and subsequent improvements to building codes have substantially higher exposures to wind risk, and by extension insurance costs, for example. However, these homes may also be better value propositions for insurance cost savings if retrofits are undertaken, and thus better prospects for PACE financing—always assuming, of course, that re/insurers are prepared to meaningfully reward those retrofits with lower insurance premiums.

This speculative cut calls out some emerging lines of tension likely to generate affordability pressures in communities rolling out PACE programs. For example, tensions may be particularly acute in areas with high concentrations of legacy residential assets built before more stringent building codes, relatively high housing cost burdens and insurance costs, significant under-addressed physical climate risk exposures, and relatively limited local government fiscal capacity

and access to property-linked financing tools. Sustained research attention to such interconnections will more extensively illuminate points where housing and climate cost burdens are rising and intersecting. Such questioning is necessary to advance deeper consideration of what climate-proofing strategies and funding tools might be best positioned to safeguard affordability and access, including and beyond PACE, and particularly for lower-income homeowners and frontline communities.

Conclusion

In the United States and beyond, urban researchers and practitioners are increasingly confronted with concerns about the links between housing and climate risks. Questions of how these impacts play out, how they can be managed, and with what implications for whom now loom large. With this paper, we have focused on one key dimension of this puzzle: the challenge of equitably and effectively financing housing climate proofing measures. We have focused on residential PACE, an important but understudied financing tool increasingly being put to work for these purposes in highly climate risk-exposed places like Florida. Our aim has been to introduce this instrument and to explore the challenges of housing affordability and systemic financial risk emerging in relation to its roll-out in Florida. These include but also extend beyond current concerns for predatory lending raised by consumer protection advocates. While some forms of financial risk related to these new tools may be addressed by tighter regulation of PACE programs and contractors (already underway in some locations), the considerations we discuss here are more structural.

In particular, we reflect on two significant financial tensions bound up with the use of PACE for climate-proofing retrofits in Florida, both of which require more scholarly and practitioner attention. The first relates to the interdependent position of PACE in relation to other forms of property-linked finance in the state. In the event of a broader collapse in any one of the interlocking financial systems that underpin Florida housing markets—namely, property re/insurance, but also mortgage and municipal finance—due to climate-induced disruptions, what will become of frontline residents and communities indebted through PACE? Second, and related to this overarching question of financial breakdown, we also flag questions of residential affordability breakpoints, as homes with PACE liens also face potentially higher re/insurance costs, property tax assessments, and other expenses alongside the prospect of asset devaluation, particularly in high-risk settings like South Florida. How might these intersecting, escalating costs challenge PACE's intended contribution?

While necessarily speculative, these questions are intended to open further discussion about the premises and limits of PACE specifically, similar uses of value capture finance for climate-proofing more broadly, and the challenges of resourcing "future proofing" in general. The privatized, individuated model of value capture exemplified with PACE raises major questions in states like Florida—even if value-added and cost savings from home retrofits materialize as hoped, there is a serious risk that broader systemic destabilizations and devaluations may swamp these value gains. This potential vulnerability to re/insurance failure suggests the need to delineate more holistic adaptation interventions, regulatory strategies, and funding streams. Such policy and financing strategies must be held accountable to a common normative question: overall, are they able to deliver effective, but also affordable and equitable, housing provision in a climate-changing world?

We have also argued for a better understanding of the costs of climate-proofing, including how it intersects with other housing affordability issues. Further research into how affordability breakpoints manifest on the ground is needed to help policymakers and housing stakeholders better design and target residential climate proofing programs, nested within broader urban and regional climate adaptation strategies. This task requires thinking about how to weave together individual, collective, public, and private financing instruments with a broader suite of physical risk reduction strategies and with considerations for non-financial values at risk. Further research must elevate the interests of those excluded from property owner-focused retrofit finance—for example, renters and rental housing stock, wholly absent from our story. Likewise, it must explore alternate pathways for residential climate-

proofing that address the need for multi-risk and multi-scalar adaptation measures and that contain safeguards for housing affordability.

Finally, this intervention raises important questions about where new climate financing solutions come from—and problems in relying too heavily on models of the past. Specific forms of individuated, privatized value capture instruments like PACE have become central to U.S. urban finance, and are arguably where policymakers and related private actors still look first for solutions to tackle climate challenges. We suggest a real need for caution if new tools are not to exacerbate the very vulnerability they mean to address. A more expansive and transformative world of resourcing for climate-proofing must, rather, re-embed the logics of progressive redistribution, resource-sharing, and collective problem-solving.

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References

Anguelovski, I., Shi, L., Chu, E., Gallagher, D., Goh, K., Lamb, Z., Reeve, K., & Teicher, H. (2016). Equity impacts of urban land use for climate adaptation: Critical perspectives from the global North and South. *Journal of Planning Education and Research*, *36*(3), 333–348. https://doi.org/10.1177/0739456X16645166

Ashton, P., Doussard, M., & Weber, R. (2012). The financial engineering of infrastructure privatization: What are public assets worth to private investors? *Journal of the American Planning Association*, *78*(3), 300–312. https://doi.org/10.1080/01944363.2012.715540

Beven, J. L., Berg, R., & Hagen, A. (2019, May 17). *Hurricane Michael (AL142018). National hurricane center tropical cyclone report*. National Hurricane Center.

Bigger, P., & Knuth, S. (2023, April 25). Pennsylvania's housing justice campaign's promising win. *Nonprofit Quarterly*.

Bigger, P., & Millington, N. (2020). Getting soaked? Climate crisis, adaptation finance, and racialized austerity. *Environment and Planning E*, *3*(3), 601–623.

Bucci, L., Alaka, L., Hagen, A., Delgado, S., & Beven, J. (2023, April 3). *Hurricane Ian (AL092022). National hurricane center tropical cyclone report*. National Hurricane Center.

Burns, R. (2021, April 6). The subprime solar trap for low-income homeowners. *Bloomberg*.

Butler, W., Holmes, T., Jackson, A., Lange, Z., Melix, B., & Milordis, A. (2022). *Addressing climate driven displacement: planning for sea level rise in Florida's coastal communities and affordable housing in inland communities in the face of climate gentrification*. Leroy Collins Institute.

Carollo, M. (2021, February 23). Tax hit. *Tampa Bay Times*. (Revised version).

Catlin, R. (1997). *Land use planning, environmental protection, and growth management: The Florida experience*. Ann Arbor Press.

Clayton, J., Devaney, S., Sayce, S., & Van de Wetering, J. (2021). Climate risk and real estate prices: What do we know? *Journal of Portfolio Management*, *47*(10), 75–90. https://doi.org/10.3905/jpm.2021.1.278

Collier, S., & Cox, S. (2021). Governing urban resilience: Insurance and the problematization of climate change. *Economy and Society*, *50*(2), 275–296. https://doi.org/10.1080/03085147.2021.1904621

Cox, S. (2022). Inscriptions of resilience: Bond ratings and the government of climate risk in Greater Miami, Florida. *Environment and Planning A*, *54*(2), 295–310. https://doi.org/10.1177/0308518X211054162

Cox, S. (2023). Bonding out the future: Tracing the politics of urban climate finance in Miami, Florida. *Journal of Urban Affairs*, 1–17. https://doi.org/10.1080/07352166.2023.2192941

Done, J. M., Simmons, K. M., & Czajkowski, J. (2018). Relationship between residential losses and hurricane winds: Role of the Florida building code. *ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering*, *4*(1), 04018001. https://doi.org/10.1061/AJRUA6.0000947

Dunning, R. J., & Lord, A. (2020). Viewpoint: Preparing for the climate crisis: What role should land value capture play? *Land Use Policy*, *99*, 104867. https://doi.org/10.1016/j.landusepol.2020.104867

Elliott, R. (2018). 'Scarier than another storm': Values at risk in the mapping and insuring of US floodplains. *The British Journal of Sociology*, *70*(3), 1067–1090. https://doi.org/10.1111/1468-4446.12381

Elliott, R. (2021). *Underwater: Loss, flood insurance, and the moral economy of climate change in the United States*. Columbia University Press.

Evans, S. (2023, May 16). Catastrophe reinsurers "in the driver's seat" for Florida renewal: Stonybrook. *Artemis*.

Financial, R. (2022, October 25). Press release: Renew financial's residential PACE program in Florida surpasses $430 million in resiliency and energy efficiency investments. *PRNewswire*.

Financing, H. R. (2022, October 11). Press release: More Florida communities offer PACE through Home Run Financing. *PRNewswire*.

Flavelle, C. (2022, October 13). Why Ian may push Florida real estate out of reach for all but the super rich. *New York Times*.

Florida Office of Insurance Regulation. (2023). *Property insurance stability report*.

Fuller, M., Kunkel, C., & Kammen, D. (2009). *Guide to energy efficiency and renewable energy financing districts for local governments*. Renewable and Appropriate Energy Laboratory (RAEL).

Gallin, L. (2022, July 22). Florida officials lash back as Demotech writes to 17 insurers over potential downgrades. *Reinsurance News*.

Girod, B. (2023, April 13). Florida home insurance crisis: Floridians brace for yet another rate increase. Here's why. *Pensacola News Journal*.

Gourevitch, J. D., Kousky, C., Liao, Y., Nolte, C., Pollack, A. B., Porter, J. R., & Weill, J. A. (2023). Unpriced climate risk and the potential consequences of overvaluation in US housing markets. *Nature Climate Change*, *13*(3), 250–257. https://doi.org/10.1038/s41558-023-01594-8

Grind, K. (2017, January 10). America's fastest-growing loan category has eerie echoes of subprime crisis. *Wall Street Journal*.

Grove, K., Cox, S., & Barnett, A. (2020). Racializing resilience: Assemblage, critique, and contested futures in greater Miami resilience planning. *Annals of the American Association of Geographers*, *110*(5), 1613–1630. https://doi.org/10.1080/24694452.2020.1715778

Harris, A. (2023, March 29). Florida's largest home insurer wants to increase rates 14%. *Miami Herald*.
Johnson, L. (2014). Geographies of securitized catastrophe risk and the implications of climate change. *Economic Geography*, *90*(2), 155–185. https://doi.org/10.1111/ecge.12048
Johnson, L. (2015). Catastrophic fixes: Cyclical devaluation and accumulation through climate change impacts. *Environment and Planning A*, *47*(12), 2503–2521. https://doi.org/10.1177/0308518X15594800
Kear, M., Meyer, D., & Wilder, M. O. (2023). Real property supremacy: Manufactured housing and the limits of inclusion through finance. *Annals of the American Association of Geographers*, 1–18. https://doi.org/10.1080/24694452.2023.2200507
Keenan, J. M., & Bradt, J. T. (2020). Underwaterwriting: From theory to empiricism in regional mortgage markets in the US. *Climatic Change*, *162*(4), 2043–2067. https://doi.org/10.1007/s10584-020-02734-1
Keenan, J., Hill, T., & Gumber, A. (2018). Climate gentrification: From theory to empiricism in Miami-Dade County, Florida. *Environmental Research Letters*, *13*(5), 054001. https://doi.org/10.1088/1748-9326/aabb32
Keys, B. J., & Mulder, P. (2020). Neglected no more: Housing markets, mortgage lending, and sea level rise. *National Bureau of Economic Research Working Paper 27930*.
Knuth, S. (2016). Seeing green in San Francisco: City as resource frontier. *Antipode*, *48*(3), 626–644. https://doi.org/10.1111/anti.12205
Knuth, S. (2019). Cities and planetary repair: The problem with climate retrofitting. *Environment and Planning A*, *51*(2), 487–504. https://doi.org/10.1177/0308518X18793973
Kohler, J., & Coryne, H. (2021, April 23). State-supported "clean energy" loans are putting borrowers at risk of losing their homes. *ProPublica*.
Kunreuther, H. (1996). Mitigating disaster losses through insurance. *Journal of Risk and Uncertainty*, *12*(2–3), 171–187. https://doi.org/10.1007/BF00055792
Mach, K. J., & Siders, A. R. (2021). Reframing strategic, managed retreat for transformative climate adaptation. *Science*, *372*(6548), 1294–1299. https://doi.org/10.1126/science.abh1894
McAlpine, S. A., & Porter, J. R. (2018). Estimating recent local impacts of sea-level rise on current real-estate losses: A housing market case study in Miami-Dade, Florida. *Population Research and Policy Review*, *37*(6), 871–895. https://doi.org/10.1007/s11113-018-9473-5
Oliphant, Z., Culhane, T., & Haldar, P. (2020). *Public impacts of Florida's property assessed clean energy (PACE) program*. Patel College of Global Sustainability, University of South Florida.
PACENation. (2022). *PACE market data*. https://www.pacenation.org/pace-market-data/
Palm, S., & Bolsen, T. (2020). *Climate change and sea level rise in South Florida: The view of coastal residents*. Springer Nature Switzerland.
Paul, G. (2023, April 4). Florida homeowners will face a projected 40 percent increase in property insurance rates. *WUSF Public Media*.
Peacock, W. G. (2003). Hurricane mitigation status and factors influencing mitigation status among Florida's single-family homeowners. *Natural Hazards Review*, *4*(3), 3. https://doi.org/10.1061/(ASCE)1527-6988(2003)4:3(149)
Ponder, C. S. (2021). Spatializing the municipal bond market: Urban resilience under racial capitalism. *Annals of the American Association of Geographers*, *111*(7), 2112–2129.
Qiu, S., & Durkay, J. (2016, January 26). *PACE financing*. National Conference of State Legislatures. https://www.ncsl.org/research/energy/pace-financing.aspx
Rose, A., & Wei, D. (2020). Impacts of the property assessed clean energy (PACE) program on the economy of California. *Energy Policy*, *137*, 111087. https://doi.org/10.1016/j.enpol.2019.111087
Sheehan, M. (2022, May 27). Florida property reforms signed into law. *Reinsurance News*.
Sherfinski, D., & Baptista, D. (2023, May 11). As climate risks rise, flood insurance costs stun US homeowners. *Context*.
Shi, L., & Moser, S. (2021). Transformative climate adaptation in the United States: Trends and prospects. *Science*, *372*, 6549, eabc9054. https://doi.org/10.1126/science.abc8054
Shi, L., & Varuzzo, A. M. (2020). Surging seas, rising fiscal stress: Exploring municipal fiscal vulnerability to climate change. *Cities*, *100*, 102658. https://doi.org/10.1016/j.cities.2020.102658
Sichtermann, J. R. (2011). Slowing the PACE of recovery: Why property assessed clean energy programs risk repeating the mistakes of the recent foreclosure crisis. *Val. UL Rev*, *46*, 263.
Táíwò, O. O. (2022). *Reconsidering reparations*. Oxford University Press.
Taylor, Z. J. (2020). The real estate risk fix: Residential insurance-linked securitization in the Florida metropolis. *Environment and Planning A*, *52*(6), 1131–1149. https://doi.org/10.1177/0308518X19896579
Taylor, Z. J., & Aalbers, M. B. (2022). Climate gentrification: Risk, rent and restructuring in greater Miami. *Annals of the American Association of Geographers*, *112*(6), 1685–1701. https://doi.org/10.1080/24694452.2021.2000358
Taylor, Z. J., & Erasmus, L. (2022). *Climate migration and real estate investment decision-making*. Urban Land Institute.
Thompson, J. J., Wilby, R. L., Hillier, J. K., Connell, R., & Saville, G. R. (2023). Climate gentrification: Valuing perceived climate risks in property prices. *Annals of the American Association of Geographers*, *113*(5), 1092–1111. https://doi.org/10.1080/24694452.2022.2156318
Thoyre, A. (2021). Neoliberalizing negawatts: Governance of energy efficiency as accumulation strategy. *Geoforum*, *118*, 140–149. https://doi.org/10.1016/j.geoforum.2020.12.012

Vejchodská, E., Hartmann, T., & Alterman, R. (2023). Land value capture: Dynamics and diversity of instruments and strategies. *Town Planning Review*, *94*(2), 116–123. https://doi.org/10.3828/tpr.2023.9

Weinkle, J. (2015). A public policy evaluation of Florida's citizens property insurance corporation. *Journal of Insurance Regulation*, *34*(1), 1–34.

Weinkle, J., Landsea, C., Collins, D., Musulin, R., Crompton, R. P., Klotzbach, P. J., & Pielke, R. (2018). Normalized hurricane damage in the continental United States 1900–2017. *Nature Sustainability*, *1*(12), 808–813. https://doi.org/10.1038/s41893-018-0165-2

Woodruff, S. C., Mullin, M., & Roy, M. (2020). Is coastal adaptation a public good? The financing implications of good characteristics in coastal adaptation. *Journal of Environmental Planning and Management*, *63*(12), 2082–2101. https://doi.org/10.1080/09640568.2019.1703656

Young, M., Cleary, K., Ricker, B., Taylor, J., Vaziri, P., Stamann, B., & Grossi, P. (2010). *Study of Florida's windstorm mitigation credits: Assessing the impact on the Florida insurance market*. Florida Department of Financial Services & Risk Management Solutions.