Cities and Planetary Repair: The Problem with Climate Retrofitting

Dr. Sarah Knuth
Department of Geography
Durham University

In the 2010s, major US initiatives framed urban retrofitting as a decarbonization solution. These programs address an obtrusive legacy of industrial capitalism: its built environments shed energy and emissions when they fall into disrepair. Political ecology and economy have been slow to engage retrofitting, an absence that is conspicuous as these fields take on planetary repair as a conceptual provocation and turn in mainstream conservation. This paper explores US retrofitting as a distinctive material repair practice, one born as an energy poverty program amid the scarcity fears of the 1970s Energy Crisis but seeing a renaissance today as a program for green capitalist growth. I interrogate two economies of repair now emerging around retrofitting, energy market and cleantech aspirations to make energy efficiency a resource and articulated efforts to sell retrofits as new green value for real estate development and investment. Such urban revaluation efforts join an expanding array of green gentrification schemes today. Paradoxically, even as would-be green entrepreneurs are drawn to these seemingly intangible and "clean" forms of waste and value-in-waiting, retrofitting presents intransigent materialities. Its decarbonization ambitions demand not just profit-generating urban repair today but large-scale urban *maintenance* into the future. This need confronts longstanding efforts to render US cities and built environments flexible to recurrent creative destruction in service of ongoing economic growth. Such logics of de/revaluation and essential disposability permit concurrent US programs for gentrification and urban abandonment today. However, decarbonization requires a more substantial confrontation with capitalist ruination-as-usual.

Keywords: retrofitting, planetary repair, green growth, green gentrification, political ecology/economy

In the 2010s, major US initiatives framed urban retrofitting as a decarbonization solution. These programs address an obtrusive legacy of industrial capitalism: its built environments shed energy and emissions when they fall into disrepair. Political ecology and economy have been slow to engage retrofitting, an absence that is conspicuous as these fields take on planetary repair as a conceptual provocation and turn in mainstream conservation. This paper explores US retrofitting as a distinctive material repair practice, one born as an energy poverty program amid the scarcity fears of the 1970s Energy Crisis but seeing a renaissance today as a program for green capitalist growth. I interrogate two economies of repair now emerging around retrofitting, energy market and cleantech aspirations to make energy efficiency a resource and articulated efforts to sell retrofits as new green value for real estate development and investment. Such urban revaluation efforts join an expanding array of green gentrification schemes today.

Paradoxically, even as would-be green entrepreneurs are drawn to these seemingly intangible and "clean" forms of waste and value-in-waiting, retrofitting presents intransigent materialities. Its decarbonization ambitions demand not just profit-generating urban repair today but large-scale urban *maintenance* into the future. This need confronts longstanding efforts to render US cities and built environments flexible to recurrent creative destruction in service of ongoing economic growth. Such logics of de/revaluation and essential disposability permit concurrent US programs for gentrification and urban abandonment today. However, decarbonization requires a more substantial confrontation with capitalist ruination-as-usual.

In the 2010s, climate change became an urban problem in a new way. In the United States, major cities announced sweeping projects of urban retrofitting in the name of energy conservation and decarbonization. Initiatives such as New York City's PlaNYC, Los Angeles' Sustainable pLAn, and Chicago's Retrofit Chicago promised to repair and modernize broad swathes of their existing built environments for improved energy efficiency, substantially reduce citywide energy use, and slash greenhouse gas emissions.[1] Meanwhile, state legislation such as California's Assembly Bill 758 and Senate Bill 350 targeted existing buildings in and beyond cities, in California's case ambitiously committing the state to double its energy efficiency by 2030. Together, such energy retrofitting programs in the United States, alongside similar efforts in Europe and other older industrial economies, are shaping an important problem space, and space of imagined solutions, for climate response. Namely, in taking on such places' existing built environments and energy practices, they prioritize these second natures "at home" – problem-location that has often eluded a global carbon economy of emissions trading, offsetting, and other geographical displacements to rural and exploitable spaces.[2] Moreover, they diverge from the green master planning visions of new eco-cities. Retrofitting takes on capitalist ruin/s more directly and intimately. Centrally, it confronts an increasingly obtrusive legacy of 20th century industrialism: that its built environments, constructed with the assumption of cheap and abundant fossil energy, chronically bleed energy and emissions when they fall into disrepair.

Political ecology has been slow to engage climate retrofitting as a movement and practice (Edwards and Bulkeley 2015, Knuth 2016),[3] even as retrofitting provokes new critical analysis amid broader debates on Anthropocene urbanism and resilience (e.g., Hodson and Marvin 2015, Hodson et al. 2016, Cohen 2017, Bouzarovski et al. 2018, and see Derickson 2018, Long and Rice 2018). This absence is conspicuous as political ecologists take on planetary repair more expansively, as a conceptual provocation for an era of global environmental destabilization and as a conflictual turn in mainstream conservation practice – particularly as technofuturist visions of ecological design and geoengineering gain new adherents (e.g., Latour 2011, Robbins and Moore 2013, Collard et al. 2015, Tsing 2015, Mansfield and Doyle 2017). Despite urban political ecology's longstanding commitment to "renaturalizing" cities, urban second natures have often been sidelined in debates on repair's political future.[4] Moreover, urban *buildings* and interior environments have been marginal concerns for a subfield preoccupied with more visibly "green" urban ecologies and networked infrastructures (although see Day Biehler and Simon 2011, Knuth 2016, Cohen 2017, Wachsmuth and Angelo 2018).[5] In this paper, I make a new intervention in these discussions. First, I explore energy (/decarbonization) retrofitting as a distinctive practice of material repair. Its sociomaterial assemblages remain geographically particular in important ways, shaped by divergent regional histories of urbanization, energy-technological modernization, disinvestment, and degradation – as well as meaningful climatological and vernacular architectural difference. Therefore, I ground this paper's survey in a specific US experience of energy retrofitting, one born in the complex political moment of the 1970s Energy Crisis. This period's brief but influential brush with energy scarcity and conservation thinking inflected welfare programs such as weatherization (in an often-buried history of energy poverty in the United States), countercultural imaginaries of alternative energy futures, and urban redevelopment and rehabilitation struggles – all significant in retrofitting's evolving politics, then and now.

More centrally, I consider what retrofitting is *becoming*. Like other prominent programs of environmental repair and restoration/redesign today, energy retrofitting is being positioned in today's US initiatives as at once a decarbonization strategy, frontier for green innovation and entrepreneurialism, and prop to capitalist accumulation-as-usual. Political ecologists increasingly critique repair and restoration's place in such green growth visions (e.g., Goldstein 2014, Mansfield and Doyle 2017). Fairhead et al. (2012) persuasively argue that "the damage inflicted by economic growth generating unsustainable resource thus creates the basis for the new growth economy of repair" in which "unsustainable use 'here' can be repaired by sustainable practices 'there', with one nature subordinated to the other" (p. 241). They argue that this interplay results in "doubly valuing nature: for its use and for its repair…in such a way as to maximise both economies – of growth and of repair – with the intent of getting the very most out of nature and with maximum efficiency" (p. 242). If retrofitting brings Fairhead et al.'s "economy of repair" home in noteworthy ways, it simultaneously reignites longstanding questions about energy efficiency's ability to achieve energy conservation. Like Fairhead et al., skeptics have long argued that such interventions may trim energy "waste" while accommodating – and even promoting – growing energy *use*. Political ecology, with often-allied degrowth advocacy

(D'Alisa et al. 2014), must therefore explore whether energy retrofitting offers more durable decarbonization possibilities despite today's green growth aspirations – and, if so, with what obstacles and delimitations.

In this paper, I therefore examine two particular econom*ies* of repair now emerging around energy retrofitting in the United States.[6] I survey material visions, value propositions, and valuation efforts in these developing green sectors – thereby advancing new insights into value in green capitalism, a theoretical project now spanning political ecology, political economy, and cultural economy (e.g., Kenney-Lazar and Kay 2017, Knuth 2017). First, I explore how retrofitting has been taken up by a wave of energy efficiency entrepreneurs, furthering market-led transformation and turbulence in the US electric power system. New accumulation visions propose "energy efficiency as a resource", value that can be profitably cultivated or mined within existing buildings (and see Knuth 2016). Such aspirations have drawn both major corporate players and "cleantech" start-ups to the sector. Together, they are shaping an important frontier within the green economy's broader waste to resource program (Gregson et al. 2010, 2016, Knapp 2016) – one with a distinctive (im)material bent. Second, I draw on urban political economy to consider the property sector that shapes these built environments, and the prospects for realizing many such green capitalist hopes. A parallel accumulation project is now developing among real estate developers, investors, would-be green financial innovators, and entrepreneurial urban governments. These players are working to translate energy retrofitting and value-added into an instrument for real estate conversion, revaluation, and speculation; for example, in drives to appraise and certify a green value premium for retrofitted properties, and to enlist future energy savings as a new revenue stream for financing building adaptive reuse. These revaluation efforts join an expanding set of green gentrification schemes today, a growing concern of urban political ecology and economy. Meanwhile, historic preservation players and other institutions with a stake in the United States' legacy built environments are generating new energy and emissions data to sell retrofitting – an exercise with unexpected radical potential.

With this first-cut survey, I draw out a central paradox of retrofitting initiatives' vision for decarbonization and/as green growth. Would-be green entrepreneurs have been drawn by the intangible form of urban-industrial waste, energy and emissions inefficiency, that retrofitting projects target as value- and resource-in-waiting: significantly, an attractively "clean" and malleable one compared to the frequently intractable, abject, and risky materialities of industrial byproducts, urban discards, and contaminated brownfield land (Gregson et al. 2010, 2016, Gidwani and Reddy 2011, Dillon 2014). Meanwhile, it offers US cleantech players enticing opportunities for light-footprint business models in green services, information technology, and financing – an important departure from the material- and capital-intensive manufacturing that frustrated the sector in the late 2000s (Knuth 2018). More fundamentally, it suggests an important accumulation frontier for economic decoupling, ecological modernization's central proposition that an innovative capitalism can detach growth from its energy and material metabolisms. This proposal requires (again, necessary but far from sufficient) the successful production of such intangible value forms, assets, and economic spaces. Indeed, I suggest that early US countercultural experiments with energy efficiency helped make green growth imaginable. However, I argue that in practice, retrofitting initiatives confront Fairhead et al.'s critique in a particularly wicked form. In their ineluctable material dependence upon urban built environments and capitalist urban interests, they enter a space hostile to their deeper decarbonization goals – and possibly even the more delimited aspirations of their green capitalist adherents. As a decarbonization strategy, retrofitting requires not just potentially profitable urban repair today but large-scale urban *maintenance* into the future – a far more demanding challenge to capitalist ruination.

Retrofitting's Roots: Weatherization and the Specter of Energy Scarcity

The Energy Crisis of the 1970s was a generative moment in US politics, in ways immediately apparent and in ways only being realized or remembered today. In recent work, Huber (2013) has tracked the influence of this jarring encounter with energy scarcity in the crisis of US Keynesianism, the rise of neoliberalism, and the birth of a new era of US oil adventurism and imperialism abroad. Domestically, the Energy Crisis influenced a broad set of contemporary debates, in ways farther-reaching than new questions about oil abundance and automobility. As I will discuss below, concerns for energy waste and conservation inflected the era's politics in spheres as diverse as electric utility politics, urban redevelopment protests, and the rise of historic preservation. However, the Energy Crisis's arguably most direct influence on the development of energy retrofitting was in the birth of the US Weatherization Assistance Program in 1976 (and see Harrison and Popke 2011). In low-income weatherization, ultimately funded through both the Department of Energy (DOE) and the Department of Health and Human Services (DHHS), the federal government has for decades paid for home energy efficiency audits and repairs for improved energy performance, with eligibility requirements that target low-income households – who, even in the energy-rich United States, continue to spend a disproportionate amount of their income on basic energy uses (Berry et al. 1997). The Energy

Crisis provided a crucial spark for weatherization efforts, as spikes in the costs of home heating oil compounded existing consumer strains like stagflation. However, the program speaks to more fundamental tensions in the spaces of high-energy capitalism.

Crucially, weatherization programs problematized, if tacitly, the built environments and embedded energy practices of previous generations: the United States' variety of industrial capitalism was in crucial ways *generated* through dedicated campaigns for urban redevelopment and building energy-technological modernization. Electric utilities, manufacturing corporations, and interested policymakers sought deliberately to promote unprecedented levels of energy consumption society-wide, and ways of everyday life organized around it (Nye 1992, Hirsh 1999). This mission required a broader revolution in building design, in programs initiated in the 1920s and expanded through the New Deal-Keynesian era – for example, the public-private campaign to produce the suburban "minimum home" and its electric appliance suite (Hise 1999). Moreover, it required a large-scale program for energy *retrofitting*, parallel public-private drives to modernize existing built environments for the new high(er)-energy capitalism – for example, New Deal programs to rewire older homes for full electrification (Tobey 1996). Such built environments now subsume high levels of energy use within taken-for-granted practices, obdurate materialities (Hommels 2005), and normalized assumptions – a process of rendering-inconspicuous that shapes energy consumption in stubborn ways (Walker and Large 1974, Shove 2003). Particularly challenging to energy conservation efforts, the spread of central heating and then air conditioning created rising expectations of atmospheric control and comfort within a vast and growing interior environment. This second nature now spans diverse climatic regions across the United States, and has spawned an array of building designs and settlement geographies marginally habitable without high energy consumption (although many energy-poor people are nonetheless required to do so). Resultant heating and cooling loads now dominate energy use in US buildings, particularly housing (DOE 2008).[7] Omnipresent but for many invisible or involuntary, such materialities present broader challenges to campaigns for energy conservation and decarbonization.

Weatherization confronted such high-energy spaces and geographies as a *problem* in a novel way – a source of vulnerability should energy subsequently become scarce or unaffordable. In response, the program pioneered practices of repair that continue to characterize many energy retrofitting initiatives. Notably, it centrally problematizes how *buildings* can waste energy. This focus does not wholly capture the many ways in which people or economic sectors may metabolize high-quality energy, "wastefully" or not (for example, through the introduction of new energy-using devices and their infrastructures). However, it turns a practical lens on buildings' vital materialities and sociomaterial assemblages (Bennett 2009, McFarlane 2011, and see Gieryn 2002, Graham and Thrift 2007).[8] Like all earth surface structures, buildings materially break down over time due to weathering and entropic processes, including biological ones (Day Biehler and Simon 2011) – dissolution that requires ongoing human maintenance interventions to slow and reverse. Meanwhile, products of a sociotechnically volatile capitalism, buildings frequently crystallize designs, technologies, and construction techniques that subsequent innovations render obsolescent – suboptimally efficient to operate in energy terms, as well as merely unfashionable (and see Weber 2002, Abramson 2016).[9] Degradation of building shells due to weathering and undermaintenace renders their interior natures permeable to surrounding environmental fluxes, leaking warm air out (or hot air and moisture in), compromising inhabitants' comfort and health, and demanding ever-increasing amounts of energy to effectively heat or cool.[10] Meanwhile, physical plant technologies such as heating systems and boilers wear out over time or are technologically superseded. Weatherization, like energy retrofitting more generally today, has thus sought to reduce building energy waste through a combination of repair (locating and patching leaks, fixing building elements like outside doors and windows) and technological modernization (replacing appliances like electric lights and refrigerators and larger physical plant elements like heating systems, updating building shell technologies such as improved wall or attic insulation, and so forth).

More immediately, weatherization efforts have been an acknowledgement, albeit fleeting and quickly marginalized, that energy scarcity remains a reality for many in the United States via unaffordability. A recurring theme in this persistent energy poverty is unequal exposure to disrepair and obsolescence in habitation and other everyday built spaces (Harrison and Popke 2011). This inequality takes multifarious forms in the United States (within a broader global geography, e.g., Silver 2016). The poor often inherit older, undermaintained buildings. Paradoxically, this process is lionized in longstanding mainstream discourses of "filtering", housing affordability via trickle-down (critiqued in Slater 2017). Alternatively, they may rely on habitation not built to last (see Harrison and Popke on the problems of weatherizing US mobile homes) or, as renters, endure landlords' causal or strategic building neglect (Smith 1979). Moreover, notwithstanding important histories of sweat equity in building and neighborhood rehabilitation (e.g., Kinder 2016) such households also have unequal access to the *means* of repair, including through legacies of racialized redlining and broader financial exclusion. In important ways, therefore, federal weatherization has operated both as an energy conservation program (the primary remit of its DOE funders) and a form of government economic redistribution (DHHS's priority, alongside direct energy bill aid and other social welfare programs). However, such redistributive power has been chronically limited in practice. Moving out of the Energy Crisis, fossil fuel interests and US society writ large clamored for a return to high energy growth, rejecting calls for broad-based energy conservation. Meanwhile, a rising neoliberalism began to pick off and undermine Keynesian welfare programs. Low-income weatherization, objectionable on both counts and dependent upon Congressional appropriations, has suffered chronically limited resources for decades – and, periodically, the threat of complete defunding (Berry et al. 1997, Tonn et al. 2011).[11]

Despite its resource restrictions, low-income weatherization has been a noteworthy example of long-term energy conservation policy – and, as such, raises important questions. Governmental assessments of the program argue that it achieves substantial energy savings for its participants (e.g., Tobey et al. 2011). These assessments provide important support for retrofitting's energy conservation potential (if not a final word, as such claims face ongoing questioning and speak in any case to a subset of retrofitting's potential clients). Critics often invoke a longer-term debate around energy efficiency, the problem of the "Jevons Paradox" (or a "rebound effect"). Derived from William Stanley Jevons' observations on coal-mining in the early Industrial Revolution, this economic model suggests that as efficiency improvements cheapen energy use, they simply encourage *more* energy use – prompting energy efficiency and consumption to grow together. This possibility presented scant challenge to earlier US energy efficiency advocacy, as Taylorists and Technocrats in the Progressive Era actively pursued efficiency-led industrial growth – a durable waste-trimming logic in industrial ecology. However, it is a central concern for eco-efficiency hopes today, for both decarbonization and green capitalism (as seen in Fairhead et al.'s 2012 related critique). Nonetheless, in retrofitting's case, the Jevons Paradox is a simplistic gloss on complex sociomaterial relations. It is by no means obvious that recipients will pour energy cost savings from repair projects back into intensified energy usage – or even into broader consumer spending, although weatherization programs may invoke such Keynesian growth benefits. As energy retrofitting programs multiply and become more expansive, these questions demand ongoing scrutiny.

Retrofitting for Green Growth: Emerging Economies of Repair

Writing during the Energy Crisis, Walker and Large (1974) outlined a more serious problem of energy conservation: that given US structural dependence (including through its built environments) on high energy consumption and/for ongoing economic growth, its proposition was rather more radical than advocates perhaps appreciated. Framed in a language of scarcity, conservation might be (barely) tolerated as a marginal program for the poor, but faced fierce resistance as a large-scale social undertaking. Unsurprisingly, therefore, today's renaissance in energy retrofitting has been accompanied and enabled by a profound shift in how it is imagined: instead of project of scarcity, it is now being framed as an opportunity for economic *growth*. The new retrofitting in many ways embodies a central proposition of market environmentalism: to use novel (re)valuation schemes and markets to turn problems like the US's high energy and emissions footprint on their heads, framing them instead as untapped resource frontiers. In the process, retrofitting's public and private advocates are targeting new populations, built environments, and sectors as accumulation opportunities. I consider two such emerging economies here.

Energy Efficiency as a Resource: Retrofitting and Energy Market Transformation

First, one key proposition driving new private sector interest in retrofitting comes from a growing array of schemes to reframe energy efficiency as a resource – a key frontier in broader market-led transformation within the US electric power system. Like weatherization, these energy market schemes have deeper roots in the 1970s Energy Crisis. As the period's rising prices and scarcity fears shook US high-energy assumptions, they further destabilized a national energy paradigm already experiencing challenges from within and without: the US electric utility system, and particularly its modernist "grow and build" model. For decades, investor-owned utilities commanding state-granted "natural monopolies" had captured increasing economies of scale from ongoing expansions in their customer base and electric services consumed, load balancing across the power grid, and rising thermodynamic efficiencies within increasingly large generation plants (Hirsh 1999). By the 1970s, the material and political bases of this growth were breaking down. Amid environmentalist challenges and rising interest in alternative energy, technologists and activist energy regulators began to experiment with new ways to encode energy efficiency and conservation into utility sector business models. National labs investigated designs for high-efficiency lightbulbs and other consumer appliances, while progressive state public utility commissions pushed for "demand side management" (DSM) and related customer conservation programs, including a broad set of retrofitting practices.

Utility programs like DSM suggested radically novel logics of commodity valuation and accumulation, ones that spoke to emerging green countercultural thinking in the late 1960s and 1970s. Specifically, DSM proposed to depart from previous industrial ecological models by monetizing not only efficiency but net energy *conservation* – defined not on open markets but in an institutional structure of price approvals through public utility commissions. The new programs represented utility spending on efficiency programs and other load management efforts as formally equivalent to new energy generated from power plant construction. In other words, it became possible to imagine energy efficiency as a *thing*, and a potentially valuable thing, in a new way: simply another resource in utilities' portfolios, if in a novel intangible form. Such unconventional and alternative energy ideas were supported by broader countercultural experimentation in centers like the San Francisco Bay Area, advanced through utopian social projects, regional policy development, and movement publications such as Stewart Brand's *Whole Earth Catalog* (Kirk 2007). Significantly, through such projects the green counterculture pioneered a new technofuturist turn in US environmental thought – one powerfully shaping cleantech and green economic imaginaries today. Influential alternative energy advocates in this countercultural milieu included figures like Brand and Amory Lovins. For example, in the sphere of energy conservation and its nascent value experiments, Lovins proffered the notion of "negawatts" to sell efficiency interventions' ability to produce an intangible but real, quantifiable, and potentially valuable product (Hirsh 1999). Such early visions not only anticipated market environmentalism's raft of similarly intangible environmental commodities like tradable carbon credits and ecosystem services (Fairhead et al. 2012), but also deeper post-industrial logics behind ecological modernization and green growth – possibilities for expansive spheres of intangible value and, ultimately, economic decoupling.[12]

In the contemporary moment, this revolution in valuing efficiency has arguably been most important for utilities' *competitors*, a rising tide of capitalist entrepreneurs who have sought to overturn 20th century utility monopolies. These mounting transformations in the US electricity sector have been supported by a wave of deregulation since the 1990s (accompanied by a wave of similar neoliberal restructuring abroad under structural adjustment programs).[13] One important justification for market restructuring was to create new opportunities for a specific *type* of competitor, non-utility energy efficiency businesses.[14] For example, in the 1990s new energy service companies (ESCOs), dramatically expanding a model also originally experimented with in the 1970s Energy Crisis, proposed to join or fully replace utilities as providers of efficiency retrofits and other functions. ESCOs specifically targeted large public and institutional buildings and campuses, complex built environments that presented repair and modernization possibilities beyond weatherization's scope - building commissioning, retrofits, project financing, and other services.[15] ESCOs' proposed profits typically have come from energy performance contracting, a specific framing of energy efficiency as a resource: they are paid out of energy costs that they succeed in saving clients. In addition, ESCOs also often market in-house or third party financing packages to cover the upfront costs of retrofits. They advertise that once these upfront costs and fees are recouped through subsequent reductions in energy and energy costs, building owners and operators will be left with years of their own valuable savings. The 2001 California Energy Crisis and Enron scandal, spurred by opportunistic speculation around the state's electricity deregulation, soured the US ESCO market for years – not least because Enron's Energy Services had helped lead this initial wave. Many private ESCOs failed or consolidated, and utilities shuttered versions started in-house. However, ESCOs again became big US business with the rise of the green economy in the late 2000s, with a new wave of growth and major expansion into sectors like commercial real estate. Leading ESCOs in the US today include massive multi-national corporations such as Siemens, Johnson Controls, Honeywell, and Schneider Electric, in a growing global market – $15 billion in 2017, and projected to double to $30.8 billion by 2026 (Navigant Research 2017).

In addition, Silicon Valley experiments with cleantech since late 2000s have generated a wave of energy efficiency start-ups, companies that now seek to seize market share from both utilities and larger ESCOs and "disrupt" their established business models. High-profile startups today such as Opower and Drift have targeted new energy efficiency markets in and beyond retrofitting, developing business models around new sectoral trends such as digitization, big data applications, device-centered behavioral energy efficiency, and demand-side "behind-the-meter" energy storage (a strategy to support the power grid management challenges of another expanding frontier of green capitalism, rapid renewable energy deployment) (e.g., Levenda et al. 2015, Knuth 2018). Meanwhile, a related set of green investment entrepreneurs such as Renew Financial and Ygrene have targeted the sphere of *finance* for retrofitting, especially for new private commercial and residential sector markets. Such companies now advertise a raft of experimental instruments such as Property Assessed Clean Energy (PACE) financing to cover clients' upfront retrofitting costs, often alongside secondary market construction practices such as loan bundling, on-selling, and asset-backed securitization (familiar property financing practices pre- and post-dating the subprime bubble). Together, such energy efficiency services and financing start-ups exemplify a broader Silicon Valley strategy for pushing its comparative advantage in a globally competitive green economy – one that disappointed aspiring US cleantech manufacturers in the late 2000s (Knuth 2018). These "Cleantech 2.0" entrepreneurs have instead looked to software, services, and other material- and capital-light business models – ones seemingly ideally placed to produce intangible assets like energy efficiency as a resource.

These energy efficiency as a resource schemes join a broader waste to resource project in the green economy. Novel efforts to revalue urban and industrial waste streams are building on longer-term industrial ecological projects to eliminate energy and resource inefficiencies, as well as more diverse legacies and geographies of industrial and municipal waste salvage.[16] Like energy retrofitting, these efforts have recently brought capitalist repair home to industrial capitalist economies – for example, in new programs to recover industrial waste streams for mining and reprocessing. Without the geographically fixed object that retrofitting possesses in urban built environments, some of this (re)location has been a product of deliberate social and environmental policy (Gregson et al. 2016, Knapp 2016).[17] Such projects are a growing concern within political ecology (including via its new interest in industrial ecology; Newell and Cousins 2015, Huber 2017). Critically, as Gregson et al. (2010, 2016) argue, these waste streams' intransigent materialities present major challenges to reframing them as "clean", innovative accumulation frontiers. All too often, waste remains stubborn, dirty, and dangerous – particularly to those who labor to process it, and the spaces that house such transformations (and see Gidwani and Reddy 2011, Dillon 2014). As a form of waste and nascent resource, energy inefficiency presents a radically different and attractive (im)material profile for management and revaluation. Indeed, Mulvaney (2014) warns that this relative cleanliness can make energy and greenhouse gas emissions waste a problematic entry within industrial ecological practices like life-cycle analysis, as corporations seize upon profitable eco-efficiency opportunities while obscuring more difficult and toxic industrial byproducts.

The Search for a Green Premium: Retrofitting and Green Gentrification

Critically, however, retrofitting projects are not creatures of energy markets alone, nor are they nearly as free to shed their material bases as some new sectors suggest. Rather, they depend in inextricable ways upon the materialities of existing urban fabrics and everyday practices, as well as upon cooperation from the entrenched assemblages of real estate development and valuation that shape these environments. How, therefore, do new projects to monetize and mine energy efficiency in buildings materialize on the ground, particularly within urban property markets? Significantly, as energy efficiency as a resource ideas have expanded today, an articulated set of practices is now emerging within spaces of real estate (re)development, public and private.

Once again, earlier encounters with energy scarcity have been generative in this activity. Low-income weatherization was not the only initiative for built environment repair developing in the United States through the 1970s, nor was it the only effort to articulate the energy and environmental significance of its practice. Environmentalist concerns joined a broader rising critique of modernist city-building, particularly the excesses of midcentury downtown redevelopment and Urban Renewal – rapid architectural obsolescence, large-scale demolitions and displacements, and the destruction of significant historical landmarks; atop farther-reaching processes of disinvestment and abandonment in older industrial cities (Harvey 1985, Zukin 1989, Cairns and Jacobs 2014, Abramson 2016). Movements for building rehabilitation, adaptive reuse, and historic preservation, collectively protesting the wastefulness of this ruination, advanced alternative visions of urban salvage and maintenance – demands for fixity that paralleled the era's broader environmental conservationist programs, and often with similar nostalgia and settler colonial elitism (e.g., in historic preservation's call to protect culturally "significant" and "original" buildings and neighborhoods; Zukin 1989, and see Collard et al. 2015). Amidst the Energy Crisis, these conversations advanced noteworthy – if, again, all too brief – critiques of the more particular *energy* wastefulness of rapid urban obsolescence and redevelopment (Smith 1979, National Trust for Historic Preservation 2009). It bears remembering here that this turn to fine-grained urban repair and rehabilitation, within both grassroots activity and government redevelopment policy, classically defined gentrification as a practice – even as the term and practice subsequently expanded to encompass more diverse interventions like new-build redevelopment (e.g., Glass 1964, Smith 1979, Davidson and Lees 2010). However, as gentrification entered the mainstream, its early energy concerns quickly fell out and were forgotten. Some of these energy and environmental roots were translated into later campaigns for green design in new construction – for example, through the development of the US Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) standard and rise of New Urbanist planning (Abramson 2016). Recently, these foundational concerns have been more explicitly excavated and resuscitated within historic preservation, as a new campaign to "green" preservation seeks to rearticulate and reconcile its project with large-scale energy retrofitting and decarbonization (National Trust for Historic Preservation 2009). Notably, the National Historic Trust's new Preservation Green Lab (2012) has developed a dedicated program of data-gathering to support energy retrofitting.

The current moment is seeing a broader uptake of energy retrofitting within mainstream real estate development, in explicit green capitalist terms. Significantly, a wave of major commercial real estate developers and investors retrofitted their property portfolios in the late 2000s and 2010s, voluntarily and via participation in new public-private decarbonization initiatives. This activity was aided by ESCOs' concurrent expansion into the private commercial property sector and the development of dedicated real estate certification and investment tools. For example, the USGBC developed a new label for retrofitting projects, the LEED for Existing Buildings: Operations and Management (EBOM) standard, a private certification that joins existing federal labels like Energy Star. Knuth (2016) provides a window into the interplay – and frictions – between energy efficiency and more expansively defined "green" retrofitting and labeling in such projects. In 2006, in the early years of the LEED EBOM standard, the USGBC reported approximately 3.3 million square feet certified nationally, a figure dwarfed by traditional new green building certifications (21.6 million square feet). By 2009, annual EBOM certifications surged to 132.5 million square feet and remained in the hundreds of millions throughout the early 2010s, surpassing new building certifications every year (Green Buildings Information Gateway 2014). Meanwhile, the urban and state level energy retrofitting policies described above worked to promote and support this wave, via large-scale retrofitting targets and the codevelopment of other tools such as retrofitting financing apparatuses – including via partnerships with new green financial institutions.[18] Many such programs also sought to expand private retrofitting in housing – so far more challenging than the commercial property sector (in this vein, see also federal programs like the Obama Administration's Better Building Challenge and stimulus-era funding spikes for low-income weatherization, accompanied by new efforts to reframe weatherization for/as green economic development; Tonn et al. 2011, Edwards and Bulkeley 2015).

These new economies of repair require dedicated programs of green valuation and market construction, in and beyond the US urban context. Such initiatives join now-extensive public-private campaigns to “green” (or re-green) gentrification more broadly defined, processes that urban political ecologists and economists are tracking in multiple forms (and see Anguelovski 2016). Significantly, many such efforts are advancing new relationships with urban (dis)repair and forms of property revaluation that may be attached to it. For example, they encompass an expansive encounter with the unruly ecologies and disorder of urban wastes and abandoned infrastructures, one now animating high-profile projects of aesthetic reappraisal, post-industrial park development, and real estate speculation (e.g., Gandy 2013, Millington 2015). They also include programs of brownfield remediation and urban clean-up – longstanding grassroots efforts now appropriated by high-value property redevelopment (Checker 2011, Dillon 2014).[19] Scholars of green gentrification are increasingly interrogating more precisely how these various forms of greening may raise urban property rents and exchange values, and how developers may appraise and appropriate this speculative premium (Bryson 2013, Anguelovski 2016). Such novel revaluation strategies are joining longer-term efforts to find and exploit urban rent gaps and land revaluation potential (e.g., Smith 1979, Weber 2002, Slater 2017).[20] Green gentrification projects might raise rents around new green amenities, mitigate rent impairments on and around dilapidated and contaminated brownfield sites, or both. As Dillon (2014) proposes, such revaluation exercises may transmute abject urban wastelands into wastelands in a classic Lockean sense: invitations to capitalist intensification and, through this “improvement”, private appropriation of resulting value. However, energy retrofitting’s entry into these repair and revaluation frontiers is only beginning to be interrogated (although see Knuth 2016, Bouzarovski et al. 2018).

I suggest that energy retrofitting adds both new value streams and tools to projects for gentrification and adaptive reuse. Drawing on today's growing pool of buildings retrofitted and certified under standards like LEED EBOM and Energy Star, real estate data analysts have given this trend fresh fuel by declaring that certified green and energy efficient buildings have become demonstrably more valuable than their non-green competitors (calculations once again particularly established for commercial real estate, although advocates make similar claims for high energy performance homes) (Rydin 2016). This "green premium" reflects multiple valuation logics (as Knuth 2016 also argues). Notably, like past shifts around modernization and property obsolescence, it is in part a creature of collective market perception and fashion (and see Weber 2002, Abramson 2016). Green real estate is quite capable of becoming more valuable simply because enough developers and investors are convinced that it is (for now). Conversely, property owners may legitimately fear that failing to jump on a greening bandwagon risks properties' future desirability to prospective tenants and investors, prompting downgrades from "Class A" investment status, diminished ability to attract tenants and command competitive rents, and, ultimately, devaluation. At the same time, energy cost savings generated through retrofitting projects suggest a calculable stream of value to capitalize into broader property exchange values and rents – a potentially less vulnerable locus of revaluation, given the capriciousness of urban real estate markets and ongoing ambiguities in precisely what use and exchange values a green premium expresses (for example, green building labels remain vague and problematic as a proxy for energy conservation and decarbonization potential, e.g., Knuth

2016). Broader energy market developments might increase this value-added. A return to high energy prices, effected through new scarcities or pricing greenhouse gas emissions, would increase the cost of energy waste and the value of efficient spaces. More recently, commercial property developers have begun to consider energy value-added as a new revenue source to fund and finance rehabilitation and adaptive reuse projects. They are adding streams of anticipated future value from retrofits, especially financed upfront via instruments like Commercial PACE, to already densely stacked value streams – from historic tax credits, transferrable air and development rights, low-income housing tax credits (for below market-rate rental housing units), and beyond.

These revaluation campaigns depend upon equally dedicated efforts to render energy improvements visible in property records and appraisal apparatuses – articulated with parallel efforts to map energy problem spaces and *de*value inefficient properties as impaired. Such initiatives have been another important project of public retrofitting programs today. For example, cities such as San Francisco, Seattle, Austin, and Washington, D.C. launched large-scale energy benchmarking efforts in the 2000s and 2010s, policies designed to officially record and track buildings' energy performance.[21] California's AB 802 established a similar benchmarking rule for commercial buildings and multifamily housing statewide. Meanwhile, in a different data-gathering register, entities like Preservation Green Lab are now highlighting other key logics for retrofitting. Using tools like life-cycle analysis, this institution is developing new pictures of both the energy required to operate buildings in various US regions (of various historical vintages) and the "embodied" energy required to build, demolish, and rebuild them (Preservation Growth Lab 2012). These calculations present a significant case for retrofitting and maintaining existing built environments, instead of removing and replacing them with new high-efficiency designs. They argue that older US buildings – especially those built before midcentury pushes for high-energy modernization and manufactured obsolescence – are unexpectedly energy efficient if maintained. This argument represents an important departure from conventional wisdom in the US context (National Trust for Historic Preservation 2009).[22] Furthermore, this analysis maintains that new high energy performance buildings might take decades of operational efficiencies to recoup energy and emissions released in their construction. These findings raise a profound question: are today's new retrofitting initiatives prepared to turn more durably to urban maintenance?

Conclusion: Decarbonization in a Restless Urban World

What does the first-cut survey presented here suggest about energy retrofitting as an urban repair program, and its possibilities for energy conservation and decarbonization? Within unfolding debates over planetary repair and its global economy, retrofitting is an exceptional project in significant ways. As it moves such practices and economies home to urban and capitalist centers, it presents more meaningful opportunities for reforming these spaces and their dynamics. This paper's discussion suggests that political ecology should take retrofitting seriously as a practice of repair, one with decarbonization outcomes that might outlive backers' current green growth aspirations. This is true despite legitimate concerns that energy efficiency campaigns (even successful ones) may not check net growth in energy consumption and greenhouse gas emissions. Significantly, in targeting existing built environments for its intervention, retrofitting addresses crucial shaping factors in energy use and emissions, in the US context and beyond.

These inconspicuous yet vital materialities are insufficiently considered in many degrowth proposals today (e.g., D'Alisa et al. 2014): embedded energy use practices such as space heating and cooling may powerfully resist programs of voluntary simplicity for the comfortable, as well as austerity, energy scarcity, and *in*voluntary simplicity for the energy-poor.

If retrofitting illuminates more durable possibilities as a practice of repair, its *economies* of repair remain far murkier. This paper has explored multiple would-be accumulation frontiers helping drive US energy retrofitting today, all of which remain works in progress. In this first-cut survey, it is certainly possible to read would-be green capitalism as an enabling force for large-scale retrofitting in the United States – its expansionary growth rhetoric and technofuturist visions have helped the practice go mainstream in ways that invocations of scarcity and wastefulness in the Energy Crisis failed to do. Ways in which retrofitting, energy conservation, decarbonization, and accumulation might run together in the near term thus represent an unusually open question. In exploring some fine-grained responses to it in the value and market infrastructures surveyed here, this discussion suggests important takeaways and, unsurprisingly, further questions for political ecological and economic research. Notably, many value propositions now emerging here, whether around energy efficiency as a resource or green real estate revaluation, do seemingly depend upon translating retrofits into demonstrable energy conservation. However, how durable such energy savings must and will be is less clear. New green entrepreneurs might succeed in collecting the more immediate fees and cuts discussed, but what about the clients charged with maintenance of these building improvements over the long term? Green accumulation and growth schemes might successfully gloss over such questions, as they expand into built environments across the United States and frontiers beyond – indeed, non-durability might simply present them new opportunities for fresh repair contracts and profits down the road. However, governmental decarbonization programs must take a more holistic and long-term view of these questions, as must critical evaluations.

Ultimately, the more pertinent dilemma here may not be the durability of energy savings from retrofitting as a practice – potential rebound effects and growth-enabling efficiencies notwithstanding. Rather, it may lie in the intransigent materialities in and upon which retrofitting must work (in contradiction to the immaterial visions of some proponents): the durability of the *buildings* its initiatives target. As the discussion above begins to suggest, decarbonization imperatives encounter serious challenges in capitalist urbanization: its geographical "restlessness" (Harvey 1985), and how such an imperative encodes material obsolescence into its built environments and assemblages. To justify their new political placement and broader revaluation, retrofitted buildings must not only be repaired but maintained and *conserved* into the future. If not, they will sacrifice not only their new emissions-averted but shed additional energy and emissions in their degradation, demolition, and disposal – significantly, echoing a problem encountered in forest carbon offsetting and other geographies of planetary repair. In urban contexts, this fixation may require sacrificing the prospect of higher returns from future building conversion or destruction. As such, it contradicts a longstanding imperative of (and tension within) capitalist urbanization, one with a long legacy in US land and property infrastructures (e.g., Plotkin 1987): that cities and built environments should be rendered flexible to recurrent creative destruction in service of ongoing economic growth.

Expanding apparatuses of gentrification in the US "return to the city" have arguably proffered a distinct urban version of Fairhead et al.'s (2012) problematic economy of repair. On the one hand, developers exploit a growing array of tools for building rehabilitation, revaluation, and adaptive reuse, including the new energy and environmental ones surveyed here. These infrastructures join more longstanding ones – even at the height of the United States' more unabashed mid-20th century enthusiasm for urban obsolescence and redevelopment, some urban landscapes were maintained by and for their inhabitants (Smith 1979). While capitalism may in theory treat all land as a financial asset and all structures upon it as therefore disposable in pursuit of an ever-evolving "highest and best use", such a project has been more partial and contingent in actual practice (Harvey 1982, Christophers 2010, Knuth 2015) – and, moreover, encounters unruly materialities like brownfield contamination in challenging, undertheorized ways (Dillon 2014). Collectively, these activities are expanding an important program of repair in US urbanism, as well as new strategies to profit from it – albeit at the cost of persistent racialized and classed displacement.[23] On the other hand, urban governments and developers have continued to elaborate upon a vast array of tools for urban redevelopment and land speculation – for writing down the value of existing buildings, foreshortening their material lifetimes, and otherwise facilitating their profitable removal and replacement (Weber 2002). More broadly, US capitalism and urbanism remain bound in conjoined geographies of regional boom and bust, growth and decline, and speculation and disinvestment – accompanied today by fresh programs of demolition within shrinking cities. The new gentrification wave has successfully rolled out *amidst* this broader volatility and urban wasting. However, to fulfill their promise(s) for decarbonization, energy retrofitting initiatives require a far tougher confrontation with capitalist ruination-as-usual.

References

Abramson D (2016) *Obsolescence: An Architectural History*. Chicago: University of Chicago Press.

Anguelovski I (2016) From toxic sites to parks as (green) LULUs? New challenges of inequity, privilege, gentrification, and exclusion for urban environmental justice. *Journal of Planning Literature* 31(1): 23–36.

Bennett J (2009) *Vibrant Matter: A Political Ecology of Things*. Durham, NC: Duke University Press.

Berry L, Brown M, and Kinney L (1997) *Progress Report of the National Weatherization Assistance Program*, ORNL/CON-450. Oak Ridge, TN: Oak Ridge National Laboratory.

Bouzarovski S, Frankowski J and Tirado Herrero S (2016) Low-carbon gentrification: When climate change encounters residential displacement. *International Journal of Urban and Regional Research*. Forthcoming.

Brand S (1995) *How Buildings Learn: What Happens After They're Built*. New York: Penguin.

Bryson J (2013) The nature of gentrification. *Geography Compass* 7(8): 578–587.

Cairns S and Jacobs JM (2014). *Buildings Must Die: A Perverse View of Architecture*. Boston: MIT Press.

Checker M (2011) Wiped out by the 'greenwave': Environmental gentrification and the paradoxical politics of urban sustainability. *City & Society* 23(2): 210–229.

Christophers B (2010) On voodoo economics: Theorising relations of property, value and contemporary capitalism. *Transactions of the Institute of British Geographers* 35(1): 94-108.

Christophers B (2018) Risk capital: Urban political ecology and entanglements of financial and environmental risk in Washington, DC. *Environment and Planning E.* Forthcoming.

Cohen DA (2017) The other low-carbon protagonists: Poor people's movements and climate politics in São Paulo. From *The City is the Factory: New Solidarities and Spatial Strategies in an Urban Age*. Greenberg M and Lewis P, Eds. Ithaca: Cornell University Press, pp. 140-157.

Collard R, Dempsey J, and Sundberg J (2015) A manifesto for abundant futures. *Annals of the Association of American Geographers* 105(2): 322–330.

D'Alisa G, Demaria F and Kallis G, Eds. (2014) *Degrowth: A Vocabulary for a New Era*. New York: Routledge.

Davidson M and Lees L (2010) New-build gentrification: Its histories, trajectories, and critical geographies. *Population, Space and Place* 16(5): 395-411.

Day Biehler D and Simon G (2011) The Great Indoors: Research frontiers on indoor environments as active political-ecological spaces. *Progress in Human Geography* 35(2): 172-192.

Derickson KD (2018) Urban geography III: Anthropocene urbanism. *Progress in Human Geography* 42(3): 425-435.

Dillon L (2014) Race, waste, and space: Brownfield redevelopment and environmental justice at the Hunters Point Shipyard. *Antipode* 46(5): 1205–1221.

Edwards G and Bulkeley H (2015) Urban political ecologies of housing and climate change: The 'Coolest Block' contest in Philadelphia. *Urban Studies*. Forthcoming.

DOE (2008) *Energy Efficiency Trends in Residential and Commercial Buildings*. Washington, DC: US DOE.

Fairhead J, Leach M and Scoones I (2012) Green grabbing: A new appropriation of nature? *Journal of Peasant Studies* 39(2): 237–261.

Gandy M (2013) Marginalia: Aesthetics, ecology, and urban wastelands. *Annals of the Association of American Geographers* 103(6): 1301–1316.

Gidwani V and Reddy R (2011) The afterlives of "waste": Notes from India for a minor history of capitalist surplus. *Antipode* 43(5): 1625–1658.

Gieryn T (2002) What buildings do. *Theory and society* 31(1): 35-74.

Glass R (1964) Introduction: Aspects of change. In Centre for Urban Studies, Ed. *Aspects of Change*. London: MacGibbon and Kee, pp. pp. xiii–xlii.

Goldstein JE (2014) The afterlives of degraded tropical forests: New value for conservation and development. *Environment and Society: Advances in Research* 5(1): 124–140.

Graham S and Thrift N (2007) Out of order: Understanding repair and maintenance. *Theory, Culture & Society* 24(3): 1-25.

Green Buildings Information Gateway (2014) Places: United States. http://www. gbig.org/places/935 (last accessed 7 October 2015).

Gregson N, Watkins H and Calestani M (2010) Inextinguishable fibres: Demolition and the vital materialisms of asbestos. *Environment and Planning A* 42(5): 1065-1083.

Gregson N, Crang M, Botticello J, Calestani M and Krzywoszynska A (2016) Doing the 'dirty work' of the green economy: Resource recovery and migrant labour in the EU. *European Urban and Regional Studies* 23(4): 541–555.

Harrison C and Popke J (2011) "Because you got to have heat": The networked assemblage of energy poverty in Eastern North Carolina. *Annals of the Association of American Geographers* 101(4): 949-961.

Harvey D (1982) *The Limits to Capital*. New York: Verso.

Harvey D (1985) *The Urbanization of Capital*. Oxford: Blackwell.

Hirsh R (1999) *Power Loss: The Origins of Deregulation and Restructuring in the American Electric Utility System*. Cambridge, MA: The MIT Press.

Hise G (1999) *Magnetic Los Angeles: Planning the Twentieth-Century Metropolis*. Baltimore: JHU Press.

Hodson M, Burrai E, and Barlow C (2016) Remaking the material fabric of the city: 'Alternative' low carbon spaces of transformation or continuity? *Environmental Innovation and Societal Transitions* 18: 128–146.

Hodson M and Marvin S, Eds. (2015) *Retrofitting Cities: Priorities, Governance and Experimentation*. New York: Routledge.

Hommels A (2005) Studying obduracy in the city: Toward a productive fusion between technology studies and urban studies. *Science, Technology, & Human Values* 30(3): 323-351.

Huber, M (2013) *Lifeblood: Oil, Freedom, and the Forces of Capital*. Minneapolis: University of Minnesota Press.

Huber M (2017) Hidden abodes: Industrializing political ecology. *Annals of the American Association of Geographers* 107(1): 151–166.

Kenney-Lazar M and Kay K (2017) Value in capitalist natures. *Capitalism Nature Socialism* 28(1): 33-38.

Kinder K (2016) *DIY Detroit: Making Do in a City Without Services*. Minneapolis: University of Minnesota Press.

Kirk A (2007) *Counterculture Green: The Whole Earth Catalog and American Environmentalism*. Lawrence, KS: University of Kansas Press.

Knapp F (2016) The birth of the flexible mine: Changing geographies of mining and the e-waste commodity frontier. *Environment and Planning A: Economy and Space* 48(10): 1889-1909.

Knuth S (2015). Global finance and the land grab: Mapping twenty-first century strategies. *Canadian Journal of Development Studies* 36(2): 163-178.

Knuth S (2016) Seeing green in San Francisco: City as resource frontier. *Antipode* 48(3): 626–644.

Knuth S (2017) Green devaluation: Disruption, divestment, and decommodification for a green economy. *Capitalism Nature Socialism* 28(1): 98–117.

Knuth S (2018) “Breakthroughs” for a green economy? Financialization and clean energy transition. *Energy Research & Social Science*. Forthcoming.

Latour B (2011) Love your monsters. *Breakthrough Journal* 2(11): 21-28.

Levenda A, Mahmoudi D and Sussman G (2015) The neoliberal politics of ‘smart’: Electricity consumption, household monitoring, and the enterprise form. *Canadian Journal of Communication* 40(4): 615–636.

Long J and Rice J (2018) From sustainable urbanism to climate urbanism. *Urban Studies*. Forthcoming.

Mansfield B and Doyle M (2017). Nature: A conversation in three parts. *Annals of the American Association of Geographers* 107(1): 22-27.

McFarlane C (2011) Assemblage and critical urbanism. *City* 15(2): 204-224.

Millington N (2015) From urban scar to 'park in the sky': Terrain vague, urban design, and the remaking of New York City's High Line Park. *Environment and Planning A* 47(11): 2324-2338.

Mulvaney D (2014) Are green jobs just jobs? Cadmium narratives in the life cycle of Photovoltaics. *Geoforum* 54: 178–186.

National Trust for Historic Preservation (2009) *Forum Journal: Positioning Preservation in a Green World*. 23.3.

Navigant Research (2017) *ESCO Market Overview*

Newell J and Cousins J (2015) The boundaries of urban metabolism: Towards a political-industrial ecology. *Progress in Human Geography* 39(6): 702-728.

Nye D (1992) *Electrifying America: Social Meanings of a New Technology*. Cambridge, MA: The MIT Press

Plotkin S (1987). Property, policy and politics: Towards a theory of urban land-use conflict. *International Journal of Urban and Regional Research* 11(3): 382-404.

Preservation Green Lab (2012) *The Greenest Building: Quantifying the Environmental Value of Building Reuse*. The National Trust for Historic Preservation.

Robbins P and Moore S (2013) Ecological anxiety disorder: Diagnosing the politics of the Anthropocene. *Cultural Geographies* 20.1: 3–19.

Romero A (2016) From oil well to farm: Industrial waste, Shell Oil, and the petrochemical turn (1927-1947). *Agricultural History* 90(1): 70–93.

Rydin Y (2016) Sustainability and the financialisation of commercial property: Making prime and non-prime markets. *Environment and Planning D* 34(4): 745–762.

Shove E (2003) *Comfort, Cleanliness and Convenience: The Social Organization of Normality*. New York: Bloomsbury Academic Publishing

Silver J (2015) Disrupted infrastructures: An urban political ecology of interrupted electricity in Accra. *International Journal of Urban and Regional Research* 39(5): 984-1003.

Slater T (2017) Planetary rent gaps. *Antipode* 49: 114-137.

Smith N (1979) Toward a theory of gentrification: A back to the city movement by capital, not people. *Journal of the American Planning Association* 45(4): 538-548.

Tobey R (1996). *Technology as Freedom: The New Deal and the Electrical Modernization of the American home*. Berkeley: University of California Press.

Tonn B, Rose E, Schmoyer R, Eisenberg J, Ternes M, Schweitzer M, and Hendrick T (2011) *Evaluation of the National Weatherization Assistance Program during Program Years 2009-2011 (American Reinvestment and Recovery Act Period),* ORNL/TM-2011/87. Oak Ridge, TN: Oak Ridge National Laboratory.

Tsing AL (2015) *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*. Princeton, NJ: Princeton University Press.

Turner F (2006) *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism*. Chicago: University of Chicago Press.

Wachsmuth D and Angelo H (2018) Green and gray: New ideologies of nature in urban sustainability policy. *Annals of the American Association of Geographers* 108.4: 1038–1056.

Walker R and Large D (1974) The economics of energy extravagance. *Ecology LQ* 4: 963.

Weber R (2002) Extracting value from the city: Neoliberalism and urban redevelopment. *Antipode* 34(3): 519–540.

Zukin S (1989) *Loft Living: Culture and Capital in Urban Change*. New Brunswick, NJ: Rutgers University Press.

---

[1] With variable promises, timelines, and metrics (e.g., per building, square foot, or across a whole building stock).
[2] Including exploitable spaces close to home, as protested in environmental/climate justice activism.
[3] Particularly in the energy/decarbonization realm I consider here.
[4] Despite metaphorical allusions to urban “gardens”, and an expansive debate on planetary urbanization, a concept that occludes many of the distinctive urban materialities discussed here.

[5] Although see its explorations of disrepair in urban infrastructures in the Global South, including for electricity (e.g., McFarlane 2011, Silver 2016). See also Kinder (2016) on DIY repair practices in Detroit neighborhoods.
[6] This discussion builds on fieldwork originally conducted on US retrofitting in 2010-2013, with recurrent follow-ups thereafter. This work has included participant observation in governmental forums and industry conferences nationally (for example, of the American Council for an Energy Efficient Economy); close reading of policies, industry publications and conference transcripts, and institutional position papers; as well as ongoing engagement with a wide-ranging technical and popular literature.
[7] Across US regions, albeit with regional climatological variations.
[8] Relations also explored by longstanding work in US cultural landscapes and vernacular architecture traditions.
[9] Although increasing operational efficiencies are hardly a guarantee in the US context – other building trends like increasing single-family home size act as countervailing forces.
[10] Ironically, in such breakdowns often enriching buildings as *more*-than-human ecologies (Day Biehler and Simon 2011) – thereby hastening their structural dissolution.
[11] Program funding was supplemented for years after the Energy Crisis by reparational levies on oil company profits. However, even at the 1988 peak of their allocations before the Obama Administration's post-2008 stimulus – during which they saw a major, if temporary, influx of funds – they only received $500 million in total federal allocations. By the 2000s, funding had declined to an average of $200-250 million annually (Tonn et al., 2011). Such chronically limited resources made for long program waiting lists and restrained program ambitions.
[12] And likely enabled such visions, though more fine-grained genealogical work is needed. Lovins and Brand have championed today's market environmentalism and ecomodernism, while Brand's various engagements suggestively bridge the green counterculture, Silicon Valley tech, and building adaptive reuse (Brand 1996, Turner 2006, Kirk 2007).
[13] One that created difficulties for utilities' DSM experiments even as it opened up new opportunities for their competitors (Hirsh 1999).
[14] As well as new independent players in renewable energy (Hirsh 1999).
[15] These early clients often had broader social and environmental remits that encouraged participation before the solidification of ESCOs' value case (and see Knuth 2016).
[16] As well as more profound industrial transformations beyond efficiency, opening up qualitatively novel technological and economic spaces, e.g., Romero 2016).
[17] And remains subject to pressures to outsource waste to less protected spaces and laboring populations, or to import these inequities within domestic reprocessing (Gregson et al. 2016). Although large industrial artifacts like ships may be "building-like" in their complexity, buildings' stubborn fixity in space and in relation to each other presents distinct geographical questions.
[18] For example, Rahm Emmanuel's ambitious plans (mostly thwarted) to use his new Infrastructure Trust to finance hundreds of millions of dollars in Chicago energy efficiency retrofits. Similarly, Renew Financial, mentioned above, was originally developed out of the City of Berkeley's retrofitting financing experiments, including the birth of the PACE model.
[19] As well as new forms of financialized extraction – see Christophers (2018) on green infrastructure repair/replacement and experimental bond financing.
[20] Particularly complex revaluation projects when urban land's real estate "improvements" and impairments are retained or unsuccessfully rendered invisible – departures from the aspirational sweeping-clean of pure locational land revaluation.
[21] For example, in 2013 the City of San Francisco required all existing large commercial buildings in the city to conduct yearly performance benchmarking and half-decadal comprehensive energy audits. Similarly, citing green revaluation objectives, the city's Office of the Assessor-Recorder now enters buildings' energy and environmental performance labels in its land records.
[22] Such calls also critique how green labels like LEED can value buildings' component parts – fuel for waste to resource revaluation – over buildings as preserved structures.

[23] Injustice which energy retrofitting may deepen in unanticipated ways – see, for example, its contributing role in London's 2017 Grenfell Tower disaster.