National Institute of BUILDING SCIENCES™

A ROADMAP TO RESILIENCE INCENTIVIZATION

August 2020

Developed by
The Multi-Hazard Mitigation Council (MMC)
Committee on Finance, Insurance, and Real Estate (CFIRE)

Innovative Solutions for the Built Environment

"While mitigating risks before disasters strike is increasingly becoming a priority for the risk conscious, achieving the goal of a more resilient nation will require efforts far beyond the status quo. To that end, A Roadmap to Resilience Incentivization offers innovative ideas for public and private sector stakeholders to consider as the nation's disaster costs continue to mount. I am confident the Roadmap will help advance the dialogue around resilience investments and promote actions that will benefit society as a whole."

Daniel Kaniewski, Ph.D., Incoming Chair,
Sub-committee on Finance, Insurance, and Real Estate
Multi-Hazard Mitigation Council

About NIBS and MMC: National Institute of Building Sciences brings together labor and consumer interests, government representatives, regulatory agencies, and members of the building industry to identify and resolve problems and potential problems around the construction of housing and commercial buildings. NIBS is a nonprofit, non-governmental organization. It was established by Congress in 1974. The Multi-Hazard Mitigation Council (MMC) is one the many councils under NIBS. MMC serves a vital national need by establishing a body of experts in a multitude of related fields of building sciences that can address the challenges associated with the identification and implementation of effective natural-hazard mitigation practices. The Council is an independent entity that informs mitigation decisions in ways that lead to effective public policy on many levels. For further information on MMC activities and products, see the Council's website (https://www.nibs.org/page/mmc) or contact the Jiqiu (JQ) Yuan, Executive Director of Multi-Hazard Mitigation Council and Building Seismic Safety Council at NIBS, email: jyuan@nibs.org, call: 202-289-7800.

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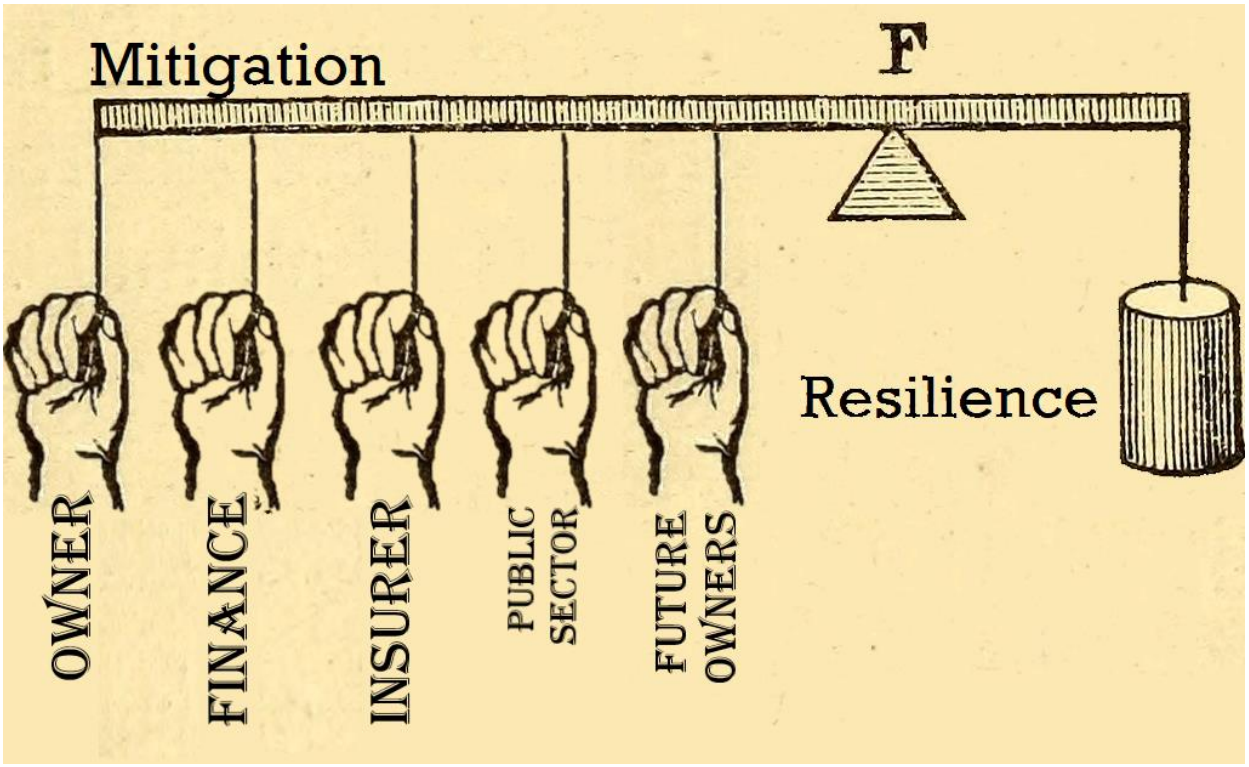
Abstract

This document proposes to develop and demonstrate a set of public and private incentives to owners of buildings and other infrastructure to facilitate the upgrade of existing infrastructure and better design of new infrastructure. America's growing disaster liability costs the nation $100 billion annually and grows 6% per year, 10 times faster than the population. NIBS' study *Natural Hazard Mitigation Saves* shows pre-disaster mitigation activities save society much more than they cost, but people have not heavily invested in mitigation, partly because owners bear the cost but receive only a small part of the benefit. The authors—resilience thought leaders from a broad coalition of public and private organizations—propose to develop of a set of incentives by which finance, insurance, real estate, and government infrastructure stakeholders share more fairly the mitigation costs. Incentives can be built into mortgages, insurance policies, tax incentives, grants, and other mechanisms. The authors propose to demonstrate the incentives in pilot communities and institutionalize them for broad implementation through a national mitigation assistance program.



How can lenders, insurers, government, tenants, and future buyers help to reduce owners' cost of resilience and thereby promote resilient communities and infrastructure for everyone's benefit? (Image: K. Porter, with permission)

Foreword

Resilience is a national issue.

Disaster losses across the country are growing about 6% a year, or 10 times faster than the population. Disasters like wildfires and floods are only increasing in frequency and volume, costing the U.S. an average of $100 billion annually. Our nation needs to be more resilient to what's on the horizon.

To a commercial building or homeowner, motivation may come in the form of incentives.

A Roadmap to Resilience Incentivization spells out concrete incentives that reduce owner costs to make new and existing infrastructure more disaster resilient. Incentives include mortgage discounts, insurance premium discounts, tax incentives, grants, and other inducements. This roadmap was developed by the Multi-Hazard Mitigation Council of the National Institute of Building Sciences.

With building codes better than they used to be and the federal government investing heavily in mitigation, you might think disaster losses might decline. But you'd be wrong. A couple of the reasons for this: We've got more people moving to higher hazard areas, and the nation adds five times as much new building area as it removes. These new buildings are not optimally resilient, adding $16 billion per year in future catastrophe losses that could be cost-effectively avoided.

Our Natural Hazard Mitigation Saves clearly shows that pre-disaster mitigation activities save more than they cost, however, investments in mitigation have not reflected the value they return. This is because the interests of all those in the supply chain – developers, owners, tenants, insurers, lenders, communities – are poorly aligned. Building owners pay extra to make a building resilient, while other stakeholders (taxing authorities, lenders, etc.) enjoy free co-benefits.

Incentives transfer co-benefits back to those who pay the initial cost of resilience. That allocates costs and benefits more fairly, aligns stakeholder interests, promotes resilience, and makes infrastructure less expensive to own in the long run.

Through this roadmap, NIBS is helping to pave a path to increase investment. We are opening up dialogue between the public and private sectors and among building science, finance, insurance, and real estate. It is our goal to put this information into the hands of those who might need it most – to increase awareness and advance our national resilience agenda, activities and investments.

Lakisha A. Woods, CAE
President & CEO
National Institute of Building Sciences

Preface and Acknowledgements

The National Institute of Building Sciences study *Natural Hazard Mitigation Saves* shows that many pre-disaster mitigation activities save much more than they cost. However, the nation has invested far less in mitigation than seems to be warranted. Why? This Roadmap was developed based on two NIBS white papers -- *Developing Pre-Disaster Resilience Based on Public and Private Incentivization* and the *Addendum to Developing Pre-Disaster Resilience Based on Public and Private Incentivization*. As the chair of the MMC Board of Direction, I would like to acknowledge the many subject matter experts from the Multi-Hazard Mitigation Council (MMC) and its Committee on Finance, Insurance, and Real Estate (CFIRE), who pioneered this important initiative. Specifically, for this Roadmap development, appreciation is due to MMC Vice Chair Keith Porter and MMC Executive Director Jiqiu (JQ) Yuan, who worked untiringly behind the scenes, developed the first draft, and accommodated all the review comments. We are also grateful for the extensive review and comments provided by Kevin Simmons from Austin College, Michael Bodaken from Bodaken & Associates, Ryan Colker from International Code Council, Michel Leonard and James Lynch from Insurance Information Institute, Leanne Tobias from Malachite LLC, Bettina Bergöö, Joel Scata and Anna Weber from Natural Resources Defense Council, Michael Zimmer from Ohio University, and Charles Scawthorn from University of California Berkeley and SPA Risk LLC.

We hope to lay out a potential path to increase mitigation investment and wish to collaborate with existing programs in other organizations. We strongly believe that real progress on resilience incentives will require collaboration across the building sciences, marrying the best available engineering with proven business practices from finance, insurance, real estate, and government. The MMC/CFIRE members who are involved and will be supporting next phase of piloting this concept include:

Organization	Name
American Institute of Architects	Rachel Minnery
Austin College	Kevin Simmons
Bodaken & Associates	Michael Bodaken
California Earthquake Authority	Janiele Maffei
CGH Consulting	Carl Hedde
Colorado State University	Bruce R. Ellingwood, John van de Lindt
Community Investment Corporation	Katherine Elmore
Department of Housing and Urban Development	Michael Blanford
Enterprise Community Partners	Laurie Schoeman
Fannie Mae	Michael Hernandez
Federal Emergency Management Agency	Kayed Lakhia, Jamie Leigh Price
IEM	Bryan Koon
Institute for Building Technology and Safety	Christopher Fennell, Joyce Coffee
Institute for Catastrophic Loss Reduction	Paul Kovacs
Insurance Information Institute	Michel Leonard, James Lynch

Insurance Institute for Business and Home Safety	Debra Ballen, Anne Cope
International Code Council/Alliance for National & Community Resilience	Ryan Colker
Los Angeles Emergency Preparedness Foundation	Brent Woodworth
Malachite LLC	Leanne Tobias
Missouri University of Science and Technology	Guirong (Grace) Yan
National Institute of Standards and Technology	Therese McAllister
Natural Resources Defense Council	Bettina Bergöö, Joel Scata, Anna Weber
Ohio University	Michael Zimmer
Pew Charitable Trusts	Colin Foard, C. Forbes Tompkins
SEFT Consulting Group	Kent Yu
Stony Brook University	Sara Hamideh
SoundView Risk Advisors	James Finlay
U.S. Green Building Council	Susan Dorn
University of Colorado Boulder and SPA Risk LLC	Keith Porter
University of California Berkeley and SPA Risk LLC	Charles Scawthorn
U.S. Resiliency Council	Evan Reis
Western University, Canada	Katsu Goda

I am proud to introduce this Resilience Incentivization Roadmap and look forward to the real collaboration across all public and private sectors to move our nation's resiliency agenda.

Bryan Koon, Chair
Multi-Hazard Mitigation Council Board of Direction

Table of Contents

Executive Summary

This document is a roadmap

This document summarizes a concrete set of complementary incentives that reduce the owner's cost to make new and existing infrastructure more disaster resilient. Incentives include mortgage discounts, insurance premium discounts, tax incentives, grants, and other inducements. The roadmap draws on two white papers by the National Institute of Building Sciences (2015, 2016). It suggests stakeholder motivations, incentivization mechanisms, and pilot studies, and outlines standards and data to institutionalize incentivization nationally.

Motivation: America's growing disaster liability

U.S. disaster losses are growing about 6% per year, 10 times faster than the population. Floods, wildfires, and other disasters cost America an average of $100 billion yearly. Losses in 2017 exceeded $300 billion—approximately $1,000 per American and about 25% of the $1.3 trillion of new construction put in place that year in the United States. Why? Building codes are better than they used to be, and the federal government continues to invest heavily in mitigation. Shouldn't losses decline instead? At least four phenomena explain the growth: (1) people are moving to higher hazard areas; (2) public expenditures to reduce natural-hazard losses are small ($1 billion annually) compared with the size of the problem (over $2.2 trillion could be saved through cost-effective mitigation); (3) the nation adds five times as much new building area as it removes; and (4) new buildings are not optimally resilient, adding $16 billion per year in future catastrophe losses that could be cost-effectively avoided.

Unfair allocation of costs disincentivizes resilience

Resilience incentivization pivots on the fulcrum of owner costs. Owners pay extra to make a building resilient, while other stakeholders (lenders, insurers, taxing authorities, and others) enjoy free co-benefits: greater safety, lower default risk, lower insurance claims, and more stable business and tax revenues. If owners bear the costs while others enjoy most of the benefits, it should surprise no one that market forces do not produce resilient buildings.

Core concept: incentives align costs and benefits

Resilience incentivization promotes resilience by more fairly sharing costs and benefits. As conceived in the NIBS white papers, incentivization comprises a set of financial instruments that transfer co-benefits back to the people who pay the initial cost of resilience. That reduces the owner's total cost of ownership,

Incentives transfer co-benefits back to people who pay the initial cost of resilience. That allocates costs and benefits more fairly, aligns stakeholder interests, promotes resilience, and makes infrastructure less expensive to own in the long run.

ideally below the cost to own a non-resilient building, making resilient infrastructure preferable in the long run.

The incentives include loan discounts and preferences; insurance premium reductions; tax incentives; grants; and others. Insurers already offer some resilience incentives. Green lending could expand into the resilience market. A variety of public-sector programs promote energy efficiency and could be expanded to better promote disaster resilience.

Economic research shows that resilience has a market value both for leasing and resale.

Pilot program and a national initiative

This roadmap presents the concepts and precedents for resilience incentives. It proposes pilot studies at the city or county level to document, demonstrate, and improve this incentivization concept with real-world examples. It proposes expanding the pilot studies into a national initiative, with guidelines, evaluation tools, requisite data, and a national mitigation assistance program that would maintain and improve the guidelines and data, coordinate outreach, and disseminate best practices among all the stakeholder groups. Such an initiative could maximize the benefit of resilience incentivization to the nation and finally reverse the exponential growth in the nation's disaster liability.

1. Background: America's Growing Disaster Liability

Disasters: $100 billion per year

The National Oceanic and Atmospheric Administration (2020) reports U.S. historical catastrophe losses (Smith and Katz 2013) showing that over the last five years, the nation has averaged 14 floods, wildfires, and other disasters each costing more than $1 billion and costing America on average $106 billion annually.

U.S. losses growing 10 times faster than population

Catastrophes in 2017 cost $319 billion in 2019 CPI-adjusted dollars, or about $1,000 per American (U.S. Census Bureau 2020). That year, the U.S. added $1.3 trillion in new construction (U.S. Census Bureau 2018), so 2017 disasters effectively unmade ¼ of that year's new buildings. U.S. disaster losses increase about 6% per year, doubling every 13 years, 10 times faster than the population's 0.6% annual growth rate.

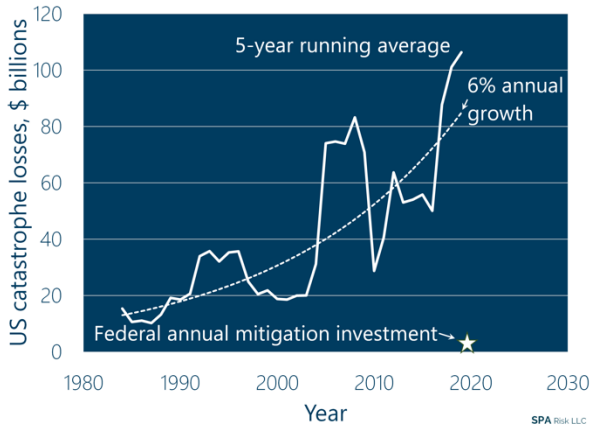


Figure 1. U.S. natural disaster losses grow 6% per year (Porter and Yuan 2020)

Why are disaster losses growing so fast?

New buildings ***should*** be more resilient than older ones. NIBS' ***Natural Hazard Mitigation Saves*** study estimates that one year of new buildings built to current code will suffer $13 billion less loss over their lifetime than if they had been built to 1990 era codes. And the federal government spends about $1 billion yearly to mitigate risk to existing buildings, ultimately preventing $6 billion in future losses (Multi-Hazard Mitigation Council 2019). Then why are losses growing at all, and which causes can be practically reversed – that is, which resilience roadblocks can be removed, and which must we accept?

Demographics partly drive growing loss

Changnon et al. (2000) and Bouwer (2011) found that population growth and movement toward higher-hazard places are the major factors driving up losses from weather–climate extremes. Höppe and Grimm (2008) suggest climate change worsens the problem. Furthermore, new construction to accommodate growth and movement add to the building stock. Construction outpaces demolition by about 3 new houses per 1 demolished (Yun 2016). Those new houses are larger: 2,500 square feet on average versus 1,500 square feet 40 years ago (U.S. Census Bureau 2019). Assuming the same trends for non-residential buildings, America's disaster liability grows partly because we add 7,500 square feet of new buildings for every 1,500 square feet of old buildings demolished. Demographic movement cannot be reversed, but we can build better where people move.

Affordability over efficiency in standards

New construction to accommodate population growth and movement adds to the liability. Model

America's disaster liability grows partly because we add 7,500 square feet of new less-than-optimally-resilient buildings for every 1,500 square feet of old buildings demolished, and the newer ones tend to be in higher-hazard areas.

building codes minimize first costs and assure life safety rather than minimizing society's long-term ownership cost. One could say that model codes optimize affordability over efficiency. Doing so adds $16 billion annually to America's long-term disaster liability that could be avoided by spending $4 billion for above-code design (a 0.3% increase on the $1.3 trillion annual construction cost). Few owners demand new construction above code because they enjoy only a small part of long-term resilience benefits but bear all of the up-front cost. Without owner demand, developers compete in a market with existing construction, so every $1 more cost means $1 less profit. This resilience roadblock ***can*** be removed, either with code changes or with incentives that make above-code design financially attractive to owners.

The problem dwarfs the public resilience budget

Public-sector incentives probably cannot succeed alone in advancing resilience. *Natural Hazard Mitigation Saves* shows that the investment gap to remediate existing buildings dwarfs public mitigation budgets. The U.S. government invests $1 billion annually in mitigation, but *Natural Hazard Mitigation Saves* shows that America's resilience investment gap exceeds $520 billion. That is, the country could cost-effectively spend $520 billion to reduce its disaster liability by $2.2 trillion. Because of diminishing returns, the next $1 billion would trim the liability by less than $1 billion and would not merit the expense, at least for the mitigation measures NIBS considered. That is, $520 billion is the incrementally efficient maximum investment for the measures NIBS considered. The NIBS study did not consider some high-value problematic building types such as older steel-frame buildings, so the $520 billion is a lower bound. Conceivably, the U.S. Congress could invest to close this gap; it committed $2 trillion in a March 2020 Coronavirus stimulus package. Where else can the country find the money to close the gap?

Private-sector resilience incentives

If public-sector funds are too small to solve the problem, let us explore how the private sector can contribute. Several private-sector stakeholder groups would enjoy co-benefits of mitigating existing infrastructure and better design of new infrastructure ***if*** mitigation were carried out. Those stakeholders include lenders, insurers, tenants, and players in the broader economy. Incentives could be designed to share the cost of mitigation more equitably, and induce owners to realize co-benefits for everyone. Public and private-sector incentives together could potentially make resilient buildings cost less to own than deficient existing buildings and code-minimum new ones.

The rest of this document explains the core concepts and offers a plan for pilot studies of resilience incentivization. It outlines data and standards needed to institutionalize resilience incentivization nationally. Conclusions and citations appear at the end of the document. This roadmap draws on incentives introduced in *Developing Pre-Disaster Resilience Based on Public and Private Incentivization* and an addendum (National Institute of Building Sciences 2015, 2016).

2. Core Concepts

Several core concepts lead to resilient construction:

- Goal: reduce consumer cost for resilient infrastructure
- Mechanism: reduce owner cost with incentives from:
  - Lenders—through mortgage incentives
  - Insurers—through premium discounts
  - Government—through tax incentives and grants
  - Tenants—with more desirable buildings
  - Future buyers—through higher resale value

2.1 Reducing Consumer Cost

To make resilient construction more desirable, basic economics suggest reducing consumer cost, increasing consumer demand, or both. So far, demand alone has not produced resilient infrastructure. The essence of resilience incentivization is to make it cost less for consumers to demand better buildings. The incentives take different forms for different stakeholders, as illustrated in Figure 2.

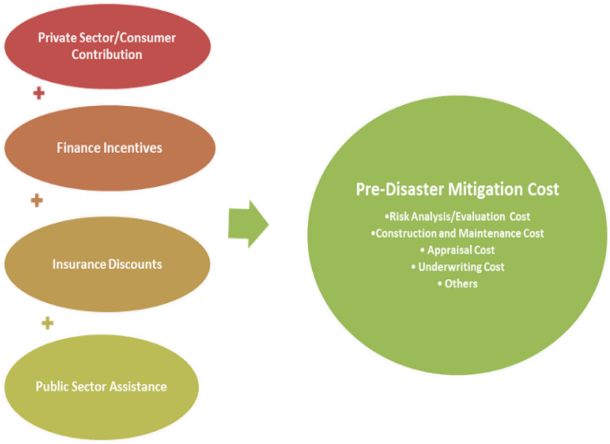


Figure 2. Bundled approach to reallocating mitigation costs

Consumer cost can be framed this way:

Consumer cost = mitigation cost – financial incentives – insurance discounts – public-sector assistance

Affordability matters. Lower costs likely increase uptake, but the relationship between uptake and cost probably varies between consumers. It may be that vulnerable populations cannot afford any additional cost; theirs might have to be completely offset with lending and insurance incentives and public-sector assistance to result in substantial uptake. For middle-class and wealthy consumers, more modest incentives might suffice, with the various monetary, safety, and psychological benefits of resilience driving up demand.

This roadmap addresses how to reduce consumer cost to make new and existing infrastructure more resilient. What other stakeholders can provide incentives, why should they do so, and how?

The present roadmap to resilience takes a market approach, but one that involves all the building stakeholders, not just demand from the consumer.

2.2 Why and How Much Should Stakeholders Help?

Why should other stakeholders help owners pay for mitigation? Understanding how they benefit helps to understand how much they should help. Later, we examine mechanisms.

- Developers briefly own buildings during construction or renovation. Today, they bear the entire extra cost to build above code. In principle, developers can transfer this added cost to owners. Resilience reduces developers' property losses and insurance costs if disasters occur during the ownership period, so they enjoy perhaps 2% of total

long-term avoided property loss and 4% of insurance benefits. See Natural Hazard Mitigation Saves for details.

- Owners. Some first owners have a say in the design of new buildings, but people tend to own houses on average 13 years (National Association of Realtors 2020), multifamily dwellings about 5 years (Perlman 2018), and similar holding periods for many other commercial real estate investments. Buildings last 75 years or more, so possibly more than 15 owners own the building later in its life. They have no design input, though they can control upgrades. If resilience has market value, later owners bear its cost, retaining part and transferring the rest to tenants. As a group, all owners receive approximately 58% of the benefits from reduced building repair costs and most (86%) avoided insurance costs, but only in proportion to their ownership period.
- Lenders usually have no input in new design. Lenders who acquire damaged property through mortgage default bear some risk and can therefore benefit from resilience. For improvements to existing buildings, some lenders encourage borrowers to consider energy efficiency and renewable energy opportunities. The same could happen for other resilience measures. Resilience reduces the chance of mortgage default that would leave lenders to pay for repairs. Those lenders enjoy 7% of property and 10% of insurance benefits.
- Tenants. Some first owners occupy their buildings, but no subsequent owners nor any tenants control first design. Tenants have little control over structural upgrades, but they can mitigate some disaster risk to furniture, fixtures, and equipment. They pay at least part of the owner's resilience costs through rent. Resilience reduces content and tenant improvement losses, approximately 33% of the property loss, 100% of lower direct business interruption and additional living expenses, and 99% of safety benefits. Tenants enjoy these benefits in proportion to the duration of their tenancy.
- Communities. Most governments have limited ability to improve building codes. Some cities have mandated upgrades for existing buildings. Resilient buildings tend to survive disasters better, remain in the tax base, and require less public response and recovery expense, providing more stable tax revenues and lower disaster costs. The rest of the economy enjoys 100% of lower indirect business interruption loss through a more stable marketplace, 100% of environmental benefits and better public service from better public buildings, and 1% of safety benefits, all at no expense.

The foregoing bullet list suggests *how* stakeholder groups benefit. What about *how much* they benefit? We can quantify how much each group pays and benefits from better buildings in total dollar terms, which can inform decisions about how much incentive each group might fairly provide to owners.

Figure 3, drawing from *Natural Hazard Mitigation Saves* (Multi-Hazard Mitigation Council 2019), shows costs and benefits for above-code flood design of one year of new construction. If all new buildings next year were built to an optimal above-code level, it would cost $900 million and eventually save $4.2 billion, an overall 5:1 benefit-cost ratio (BCR). The benefit is allocated in the blue bars above the horizontal axis, with the shades indicating benefit categories: reduced property loss, reduced business interruption, etc. The $900 million cost is shown in the red bars below the axis,

assuming half the cost is transferred to tenants. Owners see the lowest BCR, 2.5:1. First owners have no guaranteed benefit during their tenure; flooding may or may not occur during their average 13-year holding period. Later buyers may or may not pay extra for a resilient building. For these reasons and probably others, first owners do not demand resilient buildings.

What if some of the costs were transferred to other stakeholders? Figure 4 shows how transferring costs (red bars) can equilibrate BCRs, incentivizing owners to demand resilient buildings. The same concept is applicable to existing buildings. Cost reallocation would vary by situation, for example it would not make sense to transfer costs to low-income tenants.

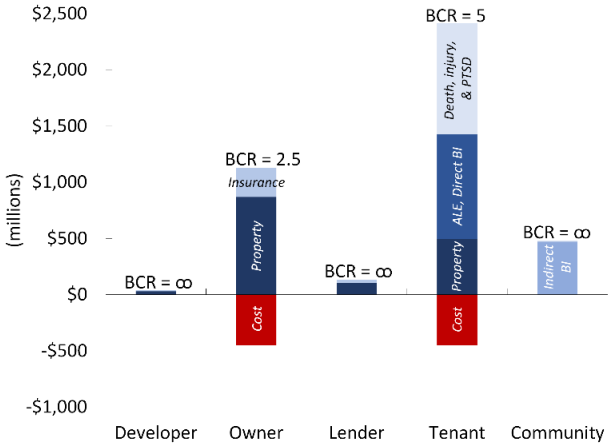


Figure 3. Unfair allocation of costs and benefits from one year of new flood resilient buildings

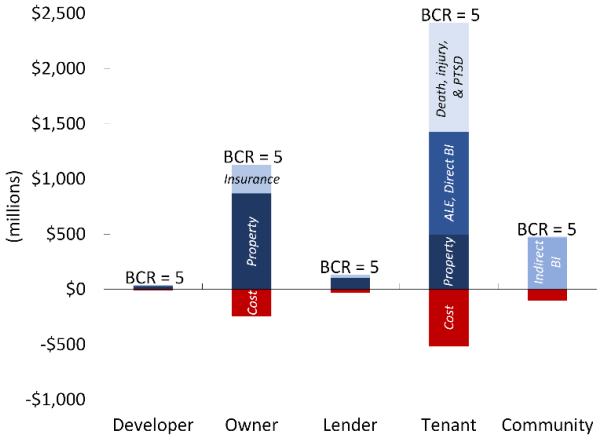


Figure 4. Reallocated costs and benefits equilibrate benefit-cost ratios

Figure 3 and Figure 4 show societal totals for a year of new construction, but they don't say how that allocation applies to a particular building. How might that work? See Table 1 for an illustration of the following case study. A developer builds a new house with 5 feet of freeboard above the 100-year flood elevation, rather than 1 foot. The column labeled "cost no incentive" shows that the developer passes the added cost of $9,000 on to the buyer, who uses the home as an income property. The owner passes half to the tenant in higher rent, as also shown in the "cost no incentive" column. Imagine incentives structured to transfer costs as shown in column 3. The cost without incentives plus the transfers lead to the adjusted costs ("with incentive") in column 4. *Natural Hazard Mitigation Saves* estimated the benefits to stakeholders as shown in column 5 ("benefit"). Column 6 shows benefit-cost ratios without incentivization. The disparities in benefit-cost ratios—the owner having the lowest one—tend to discourage the investment. Column 7 shows benefit-cost ratios with incentives with aligned interests.

Notice that the incentive raises the tenant's cost from $4,500 to $5,100 over the life of the resilience measure, which might be 75 years, or

approximately $20 per year, from $150 per year before incentives to $170 per year after incentives. Why would the tenant be willing to pay an added $20 per year? Resilience improves safety, lowers insurance rates, increases peace of mind, reduces business interruption costs and additional living expenses, and other advantages discussed later.

Table 1. Case study: resilience incentivizes for flood-resilient construction

Stakeholder	Cost			Benefit	Benefit-cost ratio	
	No incentive	Transfer	With incentive	Benefit	No incentive	With incentive
Developer	$-	$90	$90	$420	∞	4.7
Owner	$4,500	($2,100)	$2,400	$11,000	2.5	4.7
Lender	$-	$290	$290	$1,300	∞	4.7
Tenant	$4,500	$670	$5,100	$24,000	5.4	4.7
Community	$-	$1,000	$1,000	$4,700	∞	4.7
Total	$9,000	$-	$9,000	$42,000	4.7	4.7

2.3 Developers, Owners, and Future Buyers

Natural Hazard Mitigation Saves estimates that owners enjoy between 20% and 58% of all societal benefits from above-code design, which amounts to between $0.72 and $3.62 per $1.00 invested, in addition to any benefits they enjoy as owner-occupants. Benefits derive from:

- Lower property repair costs
- Lower costs of lost rent during repairs
- Lower insurance costs
- Greater resale value

Future buyers provide an incentive to improve resilience through the promise of higher resale value and greater speed.

Figure 5. Home buyers value hurricane-resilient buildings. IBHS FORTIFIED Home Hurricane certification increases resale value by 7%. (Image: Pikist.com, public domain)

2.4 Lenders

Natural Hazard Mitigation Saves estimates that lenders save $0.08 to $0.42 per $1.00 that developers and owners invest in above-code design. But because few dollars are invested, lender balance sheets only potentially, but do not actually, improve. Who are the lenders, how do

they benefit from resilience, what incentives can they provide, and what evidence argues for an incentives program? Lender categories include:

- National for-profit banks
- Government programs: HUD FHA, VA loan, EDA Revolving Loan Fund Program, DOE and HUD energy efficient mortgage, SBA 504 Loan and First Mortgage Loan Program, USDA 502 Guaranteed Loan Program, etc.
- Secondary mortgage market: Fannie Mae and Freddie Mac
- Mission-driven lenders: community development financial institutions including banks, loan funds, credit unions, and venture capital firms
- Resilience-based real estate investment trusts, private equity funds, revolving funds, pension funds, retirement funds

Mortgages for resilient buildings of all kinds improve lenders' bottom line:

- Stronger collateral and lower default risk
- Greater affordability to low-income households to meet federal lending requirements
- A more stable economy through societal resilience

Lender incentives can be based on existing programs in other industries. How might lenders structure those incentives?

- Quantify how borrower repair costs and revenue interruption in future disasters represent real, if non-standard, liabilities, and that resilience both reduces these liabilities and increases resale value. Doing so would improve debt-income ratio for new loans on resilient property.
- Discounted interest rate or lower closing fee. For example, the lender in the Table 1 case study could offer a $290 rebate at closing.
- Integrate resilience into existing green lending products.

Some evidence that resilience makes safer collateral:

- Home buyers value wind resilience. IBHS FORTIFIED Home Hurricane designation increases Alabama home resale value 7% (Awondo et al. 2016). Mayor Tim Kant, of Fairhope, Alabama, told attendees at a 2016 White House event that implementing FORTIFIED made Fairhope one of the most desirable places to live in Alabama (US Government Printing Office 2016).
- Home buyers value flood resilience: In one community, homes built three feet above the 100-year floodplain sell faster than lower homes (U.S. Government Accountability Office 2015, p. 16).
- Commercial tenants value resilient workplaces. Marshall and McCormick (2015, pp. 3-5) show that a variety of medical, resort, and mixed-use developments with better climate and weather resilience enjoyed better financing options, lower insurance premiums, and greater sales.
- Owners who reduce their flood risk enjoy lower insurance costs and higher coverage limits, enhancing their financial stability and thereby reducing the lender's risk. See for example Enterprise Community Partners Inc. (2015 p. 20).

The foregoing evidence is strong, but NIBS seeks to build on it with applied research as follows:

- Additional study like that of Awondo et al. (2016) to measure the resale value of homes resilient to earthquake, fire, or flood. This shows how greater resale value should be integrated into the mortgage pricing and other underwriting decisions.
- Statistical study of the speed of sales of flood-resilient homes suggested by U.S. Government Accountability Office (2015).
- Insight from discussions with U.S. appraisers and realtors.
- Examine how resilience could be combined with or imitate energy efficiency mortgages (Box 1).

Figure 6. Fannie Mae's Green Rewards program offers lower pricing, additional loan proceeds, and other incentives to finance green property improvements. (image: CC0 public domain)

Box 1. Resilience and Green Mortgages

1. Fannie Mae designed its Green Rewards program to address barriers to financing energy efficiency upgrades in multi-family buildings. Fannie Mae delegates lending to private third-party lenders. The program improves lending ratios for refinancing to encourage green renovations. Loan to value (LTV) maxima increased from 80% to 85% of asset value, requiring 5% less equity from owners. Debt service coverage ratios (DSCR), which represent a ratio of a building's annual cash flow to what the borrower owes the bank, can be lowered from 1.20 to 1.15. For borrowers, 5% of refinance loan proceeds must be applied to property renovation or energy retrofits (McEwen and Miller 2018, pp. 18-19). Green Rewards could be expanded to include additional resilience measures, enhancing its current focus on solar generations, and energy and water efficiency.
2. Freddie Mac's Green Advantage program rewards multi-family borrowers who improve their properties to save energy or who already have green-certified properties and are looking for new financing. Green Up borrowers, who commit to improvements based on a Green Assessment and can save 15% in energy or water usage, get up to 50% of their projected energy savings underwritten. Green Up Plus borrowers, who commit to making improvements based on a highly detailed property analysis based on an ASHRAE Level 2 energy audit, get up to 75% of projected energy savings underwritten. A similar program could be developed to finance resilience efforts.
3. Commercial property assessed clean energy (CPACE) financing can fund resilience improvements that make buildings more resistant to disasters and other threats. Many of these projects have an energy component (e.g., energy efficiency, distributed generation, and microgrid), but others do not (e.g., seismic retrofits and wind hardening) (U.S. Department of Energy 2018).
4. Green banks in the clean energy industry use limited public dollars to leverage greater private investment and spark consumer demand. Green banks could expand their mission to finance other resilience measures and to accelerate resilience market growth.

Lenders should consider the following open questions:

- How much does the financial industry want greater disaster resilience from the building stock and why?
- What programs already include mitigation?
- How can disaster resilience be married to existing green lending programs?
- What technical or other professional barriers will appraisers and underwriters have to overcome to understand and advance disaster resilience?

2.5 Tenants

Natural Hazard Mitigation Saves authors estimate that tenants (including owner-occupants) enjoy between 31% and 61% of total societal benefits for above-code design. Considering the benefit-cost ratios, these benefits amount to between $1.19 to $2.71 tenant benefit per $1.00 of added cost. How do tenants benefit from resilience? What incentives can they provide? What evidence argues for an incentives program? Tenant benefits include:

- Reduced property losses
- Tenant and visitor safety
- Lower direct business interruption and added living expenses
- Lower insurance costs
- Peace of mind
- Increased likelihood of securing debt financing
- Enhanced sales prospects
- Retention of business and employees
- Less displacement; greater long-term viability and stability

Some tenants (though not all) can afford to provide an incentive through higher rent. The Applied Technology Council (2009) estimated that the cost of retrofitting soft-story high-occupancy residential woodframe buildings in San Francisco could be paid for entirely by a less than 10% rent increase. To offset owners' costs to seismically retrofit soft-story woodframe buildings, the City of San Francisco Rent Board allows landlords to pass 100% of costs to tenants, subject to appeal by tenants facing hardship (San Francisco Department of Building Inspection ND).

What evidence suggests that some tenants would be willing to pay more rent for resilient buildings? The San Francisco Community Action Plan for Seismic Safety, which developed the soft-story retrofit plan, was largely led by a volunteer advisory committee that included many tenants. They, along with owners and other stakeholders, recommended allowing the rent pass-through as part of the retrofit program (Applied Technology Council 2009).

For more evidence, recall from the lenders section that Marshall and McCormick (2015, pp. 3-5) show that a variety of medical, resort, and mixed-use developments with better climate and weather resilience enjoyed better financing options, lower insurance premiums, and greater sales.

And remember that if tenants provide their incentive in the form of a rent premium, the cost is spread over the life of the lease or even of the property, reducing the pain of the expense.

2.6 Insurers

The authors of *Natural Hazard Mitigation Saves* estimate that insurance overhead and profit costs drop by $0.07 to $0.17 per $1.00 of total societal benefit. Because of the 5:1 benefit-cost ratio, those amounts equate with $0.33 to $0.86 per $1.00 of

cost invested in above-code design for riverine flood, hurricane surge, or hurricane wind. Insurers already reward mitigation activities through competition and regulators require that rates reflect risk.

However, because it can be costly to estimate the benefit of resilience, some are unrewarded or improperly rewarded. For example, the California Earthquake Authority (2020) provides a 21% discount for seismic restraint of manufactured housing. The authors of *Natural Hazard Mitigation Saves* found that engineered tie-down systems reduce average annual ground-up monetary losses by more than 95%, suggesting a too-small incentive.

Who are the insurers, how do they benefit from resilience, what incentives can they provide, and what evidence argues for an incentives program? Insurer categories include:

- Primary carriers, who insure owners and occupants
- Reinsurance companies, who insure insurers
- Public insurance programs, such as the Federal Insurance and Mitigation Administration (FIMA) and California Earthquake Authority

Insurers benefit from resilience through:

- Lower claim frequency per policy, so lower adjustment costs
- Lower claim severity per claim
- Lower 250-year loss and thus lower reinsurance costs
- More stability in the insurance and reinsurance industries

Several studies confirm that resilience saves insurers. Simmons et al. (2020) report that homes built to the 2001 Florida Building Code that were struck by Hurricane Charley experienced 40% to 70% less damage and 60% fewer claims than buildings built to the predecessor codes, which in much of the state was the 1968 Southern Standard Building Code. Fewer and less costly claims argue for insurance incentives in the form of actuarially sound premium reductions based on lower risk. Box 2 lists some of the existing insurance discount programs that could serve as a pattern for insurance resilience incentives.

Many insurers understand the benefits of better buildings and provide appropriate incentives, for example:

- National Flood Insurance Program (2020) offers discounts up to 45% based on Community Rating System (CRS) rating
- California Earthquake Authority (2020) offers premium discounts up to 25% for seismic retrofits
- Florida Office of Insurance Regulation (2005) requires all residential property insurers to offer wind mitigation credits: discounts for building features that reduce wind damage
- Insurers offer similar discounts for fire-resistive features

A resilience incentivization program for insurers could expand public knowledge of the insurance benefits of resilience, such as the benefits of engineered tie-down systems just discussed, so that insurers could more thoroughly reflect resilience benefits in pricing.

In addition to premium incentives, what other solutions can we explore for insurers to better share the benefits they enjoy through incentives to the developers or owners who invest in preventive risk mitigation? More capacity, better terms, others? How do we get regulatory buy-in? How can we ensure that applied research meets actuarial quality requirements?

How can we know that insurers would want to be involved in resilience incentivization? Answers are needed to these questions:

1. How much do insurers want greater disaster resilience from the building stock
2. What programs already include mitigation?
3. What technical, legal, or other professional barriers must underwriters, agents, and brokers overcome to understand and advance disaster resilience?

Figure 7. Insurers already offer incentives for some resilience measures. (Image: Andrea Booher, public domain)

Box 2. Existing Insurance Discount Programs

1. Several states mandate insurance discounts or credit programs. Florida, Louisiana, Maryland, Mississippi, New York, South Carolina, and Texas require rate filings to include discounts, credits, rate differentials, or reduction in deductibles for properties with wind-resistant features (Rollins 2013, p. 2). For example, Florida insurers must provide premium discounts to residents who install wind-resistant features (Fla. Stat. Ann. § 627.0629). Available discounts range up to 87% of the hurricane windstorm portion of insurance premiums (Florida Office of Insurance Regulation 2009, p. 32). The California Earthquake Authority (CEA), which provides earthquake insurance in California, offers a 5% premium discount on retrofitted homes (Adams 2018, p. 10).
2. State Farm Insurance offers a premium discount to Texas customers who install impact resistant roofs (IRRs). IRR products have expanded in availability from ten in 1998 to more than 1,000 by 2003. According to State Farm, consumers now demand the IRR product and are disappointed if a contractor does not provide it.
3. A 2018 Alabama law allows IBHS FORTIFIED designation to serve as enough documentation of wind mitigation work for homeowners to claim mandatory premium discounts (Alabama Secretary of State 2018).
4. United Services Automobile Association (USAA) encourages wildfire resilience with premium discounts for members in communities recognized by the Firewise Communities/USA program in California, Colorado, and Texas. The National Fire Protection Association (NFPA) administers Firewise and provides a 5-step template for wildfire safety at the neighborhood level. Participating communities follow these guidelines to achieve initial recognition and then commit to annual activities to maintain this status (NFPA).

2.7 Government and the Broader Community

The authors of *Natural Hazard Mitigation Saves* counted benefits to government among community mitigation benefits. They estimate that every $1 of benefit from above-code design provided taxing authorities, other government agencies, and those who trade with owners and occupants with $0.11 to

$0.14 of benefits. Approximately 24% of those benefits—$0.02 to $0.04 per $1.00 of benefit—would contribute to tax revenues (24% based on 2018 U.S. tax-to-GDP ratio; OECD 2019). Who are the governments, how does mitigation benefit them, what incentives can they provide, and do government incentives really work? Governments include:

- The U.S. Treasury and agencies that address mitigation: FEMA, HUD, SBA, EDA, DOT, DOE, VA, USACE
- State revenue departments and state agencies: fire and offices of emergency services
- Cities and their agencies: fire, EMS, local utilities, building and safety departments, emergency managers
- Counties and their agencies: fire, EMS, building and safety, emergency managers, floodplain managers
- Other public utilities and their emergency managers

Mitigation benefits governments in several ways:

- Reduces public funds and labor spent to respond and recover from disasters and provides tax relief for covered losses. Lower response and recovery costs, under the Disaster Recovery Reform Act (DRRA) of 2018, result in lower expenditures for BRIC.
- Increases federal, state, and local sales, property, and income taxes through a more stable economy and better buildings.
- Improves local reputation to attract and retain residents and businesses; more jobs, construction, business, as shown by the foregoing story about Fairhope, Alabama.

Mechanisms to provide incentives include:

- Federal, state, or local tax credits like the Federal Solar Investment Tax Credit (EPA 2019), which allows a deduction up to 30% of the cost of a residential or commercial solar energy system.
- Real property transfer tax refunds like Berkeley, California's Seismic Retrofit Refund Program (City of Berkeley 2019).
- Federal or state grants like FEMA's Building Resilient Infrastructure and Communities program (Federal Emergency Management Agency 2020).
- Loan programs like those of the California Energy Commission (2020) Energy Conservation Assistance Act.
- State regulations to facilitate insurance and mortgage incentives, like the previously mentioned Alabama law encouraging FORTIFIED designation and mandatory insurance incentives.
- Resilience banks similar to or extended from green banks like the Connecticut Green Bank (2020).
- Accelerate local permitting and inspection procedures for mitigation, e.g., with standard plans and resolutions like those of Association of Bay Area Governments (2016).
- Some towns like Newton, Massachusetts adopt sustainable design requirements for new municipal buildings (Barrer 2018).

- Revolving loan funds like the Clean Water State Revolving Fund (EPA 2020).

See Box 3 for a wide variety of successful programs. What more needs to be done?

1. Develop model tax credit legislation
2. Develop model ordinances for real property transfer tax refunds
3. Draft regulations to use BRIC funds for above-code, hazard-resistant design
4. Expand the mission of green loan programs and green banks to address hazard mitigation and provide the guidance they need to assess loans
5. Develop standard plans for retrofit and design provisions for above-code design

Figure 8. FEMA purchased the home of Joe Moore of Arnold, Missouri, in 1993, at pre-flood value. Asked if he misses his neighborhood and his home of 19 years, Joe Moore can only laugh. "I put sandbags around that old house a dozen times.... I fixed up the basement more times than I like to remember. There was no way in the world I wanted to do any of that again.... 1993 was my last flood." (Image: Andrea Booher, public domain)

Box 3. Existing Public Sector Programs

1. Some governments have provided mitigation grants directly to residents using pre-approved, cost-effective strategies. Florida implemented such a strategy after the 2004 and 2005 hurricane seasons. Its Task Force on Long-Term Solutions for Florida's Hurricane Insurance Market made numerous recommendations, including one from the Federal Alliance for Safe Homes (FLASH) to create a Mitigation Consumer Assistance Program. The program would provide free retrofit inspections, retrofit grants for low income families, and low- or no-interest loans for proven mitigation methods. In 2006, the state created the Florida Comprehensive Hurricane Damage Mitigation Program and appropriated $250 million (Florida State University 2010, pp. 12-13). By 2007, FLASH had completed for the state 14,116 inspections, 400 quality assurance inspections in 17 counties, developed an inspection report that included return on investment for mitigation options; developed a curriculum to qualify inspectors and contractors; and created a rating scale. In 2007, the state took over full implementation. By 2009, the funding had paid for 401,372 home inspections and $82,650,215 in mitigation grants (Florida State University 2010, p. 18). By then, 40% of residential policies in the state were receiving windstorm mitigation discounts, with an average premium reduction of 26%. (Florida Commission on Hurricane Loss Projection Methodology 2010, p. 21.)

"I put sandbags around that old house a dozen times.... I fixed up the basement more times than I like to remember. There was no way in the world I wanted to do any of that again.... 1993 was my last flood." – Joe Moore, Arnold Missouri

2. South Carolina modeled its South Carolina Safe Home Program on the Florida Program and asked FLASH to develop eligible mitigation activities, provide training programs for both inspectors and contractors, and assist with development of inspection protocols and accompanying forms. The program provides matching or nonmatching grants (based upon income, as per U.S. Department of Housing and Urban Development guidelines, and the value of the home) not to exceed $5,000 to retrofit properties to increase resistance to hurricane and high-wind damage. Since the program began in 2007, it has awarded more than 3,900 grants totaling more than $17.7 million (South Carolina Department of Insurance 2015, p. 26). The program is funded through 1% of annual premium taxes.
3. Louisiana offers residents a tax deduction of up to 50% of the cost paid to bring existing homes into compliance with the building code and provides sales tax exemptions on the installation of storm shutters (Adams 2015, p. 6).
4. Alabama passed a law in 2011 that allows homeowners to qualify for a $3,000 state income tax deduction if they retrofit or upgrade their homes to FORTIFIED standards.
5. The City of Berkeley, California, provides a seismic retrofit refund on its 1.5% real property transfer tax for residential property. The program allows for up to one-third of the transfer tax (0.5% of the purchase price of the dwelling) to be refunded for voluntary seismic upgrades to residential property (City of Berkeley 2019). Within 10 years of the program's inception in 1992, 40% of single-family homes had been voluntarily retrofitted (EERI Northern California Chapter 2020). Between 2003 and 2014, the city provided 1,400 refunds, an average of 130 retrofits per year in that city of 113,000 people (Daniel 2015). The program costs the city very little since the buyer is paying for the retrofit.
6. Chicago implemented streamlined local permitting to encourage green construction (Rainwater 2007, p. 32), a concept that could be exercised for enhanced resiliency as well.
7. San Francisco expedites permits and waives fees for voluntary seismic retrofits (San Francisco Dept. of Building Inspection 2010).
8. The Alaska Division of Community and Regional Affairs and the Alaska Division of Homeland Security and Emergency Management have advocated incentives including tax abatement, density bonuses, and waiving parking requirements to encourage developers to locate projects outside of hazardous areas and to adopt hazard mitigation measures above legal requirements (Cox et al. 2012, p. 39).

3. Pilot Programs

The foregoing evidence shows incentivization makes financial sense. The resilience incentivization concept has received broad support from experts representing a wide range of organizations, including finance, insurance, builders, and government. However, much remains to be done to implement the concept, beginning with pilot studies.

Pilot studies at the city or county level could document, demonstrate, and improve this incentivization concept with real-world examples. The studies will identify programmatic approaches to incentivize owners to upgrade existing buildings or contract for the construction of new, above-code buildings. Such approaches have two objectives:

- Allocate mitigation costs fairly among stakeholders
- Establish new ways of financing mitigation

Pilot program outcomes could include documentation of:

- Best engineering practices in enough detail for practitioners to use broadly without substantially greater expertise
- Estimated costs and benefits in enough detail that owners can judge the financial implications of their resilience options
- Financial incentives, e.g., insurance premium reductions, mortgage rebates, leveraged financing, and tax and other public-sector incentives
- The interest and capacity of finance and insurance industries to implement incentivization
- The interest of owners to use the incentives to upgrade existing and new buildings
- A plan to initiate public assistance programs
- A detailed plan to institutionalize the incentivization program developed in the pilot study (as outlined in the next section)

The pilot program would test the appetite, interest, and capacity of the finance and insurance industries. The program would investigate and help initiate public resilience assistance programs at a local level. And more importantly, pilot studies would examine the willingness and capacity of different consumers to participate in incentives-based resilience. Guidelines would be produced so that the program could be replicated.

4. Resilience Incentivization – a National Initiative

To do the most good for the most people, incentivization must become a national initiative that brings together a wide range of stakeholders, initiates dialogue, develops principles and guidelines, and encourages information exchange. But developing such a national initiative requires proving the concept at the local level. For any given project, resilience incentivization is local: responding to local interests, hazards, buildings, risk attitude, culture, resources, and politics. Pilot studies will test core concepts and gather real-world experience that eventually will be standardized to scale up and to make incentivization benefit the whole nation. Additionally, a national initiative requires a national mitigation assistance program to maintain and disseminate these resources.

4.1 Resilience Guidelines

Model building codes provide a minimum level of protection and resilience to owners, occupants, and communities. Adopting and enforcing the latest code is probably the easiest, most common, and most effective way to improve community resilience. But current codes do not aim to ensure that buildings survive disasters. By aiming for less than resilience, current building codes actually cost downstream owners, tenants, and the broader community many times what they save the developer or first owner.

In fact, there are no standard guidelines for the broad community of resilience professionals—engineers, owners, lenders, insurers, and governments—to quantify the resilience of new or existing buildings. *Natural Hazard Mitigation Saves* documents a large study of costs and benefits of a variety of mitigation measures on a nationwide scale. It draws on a large body of FEMA and other resources for engineers to audit and improve flood, wind, earthquake, and fire resilience. But to institutionalize incentivization, resilience professionals will have to be able to characterize available options and quantify costs and benefits for individual projects. A set of guidelines could address each of a variety of professions:

- Engineering best practices: resilience options and procedures to quantify costs and benefits for a wide variety of projects for new or existing infrastructure.
- Lender guidelines: procedures for lenders (e.g., green lenders) to estimate the loan implications of a proposed resilience project, and to implement standard lending incentives.
- Insurer guidelines: procedures to assess the underwriting implications of a proposed resilience project and to implement standard insurance incentives.
- Tax and government resilience guidelines: procedures for tax assessors to estimate implications of a resilience project for local, state, and federal tax revenues, and for governments to implement standard tax and regulatory incentives.
- Realtor guidelines: procedures for understanding and explaining the values of common resilience options to buyers and sellers.

4.2 Evaluation Tools

Implementing quantitative guidelines will require cost and benefit data. A standardized methodology could be implemented in computer software and standard rating systems to assess the economic value of loss reductions from each of many resilience strategies. To be practical,

these tools would have to be easily used and understood by appraisers, underwriters, brokers, agents, and consumers. And they could be supplemented by more in-depth analysis by architects and engineers.

Many relevant evaluation tools and methodologies already exist in the public domain. Some private-sector entities have also developed rating systems. Some address narrow questions that do not inform existing federal program requirements, such as benefit-cost ratios for grant applications. Some may not reflect current research and practice. It may be necessary to adapt or enhance these tools or add new ones to serve the needs of the program suggested here. Doing so involves coordinating with all the stakeholder groups discussed here.

4.3 A National Mitigation Assistance Program (NMAP)

Guidelines should evolve over time, just as building codes and financial practices do. New benefit-cost analyses will likely quantify more mitigation options or delve more deeply into those already examined by NIBS and others. A National Mitigation Assistance Program (NMAP) can coordinate among sectors to maintain and improve the guidelines and data. It could coordinate outreach and disseminate best practices among all the stakeholder groups to maximize the benefit of resilience incentivization to the nation.

Real progress on resilience will require collaboration across the building sciences, marrying the best available engineering with proven business practices from finance, insurance, real estate, and government.

5. Conclusions

U.S. infrastructure has a large and growing disaster liability. The country has at least a $500 billion resilience investment gap—the amount of money that could be spent cost effectively to reduce its liability—and could save at least $2 trillion by such cost-effective resilience measures. The liability and investment gap grow in part because the interests of developers and first owners diverge from those of society at large.

Natural Hazard Mitigation Saves shows that a wide variety of resilience measures save far more than they cost, in some cases and locations as much $30 saved per $1 spent. The problem is that, while many resilience measures make sense at the societal level, such measures do not make financial sense to the people who would have to pay for them.

This roadmap lays out a set of financial incentives to align the interests of developers and first owners with those of the rest of society. The incentives will reduce the owner or developer costs to share the costs and benefits of resilience more fairly across society.

This document has provided a roadmap toward incentivization. It demonstrates how each stakeholder group has a role to play in incentivization: lenders, insurers, government, tenants, and future owners. It explained how they each benefit, how they might offer incentives, and evidence to show that analogous incentives have worked in the past.

The roadmap includes pilot programs to implement and test these incentives in sample communities, and a system to institutionalize the incentives once they are tested and refined in the pilot studies. It calls for the building professions, finance, insurance, real estate, and government to carry out this work for the good of the nation.

Real progress on resilience will require collaboration across the building sciences, marrying the best available engineering with proven business practices from finance, insurance, real estate, and government.

Figure 9. Consumer demand is not enough. Resilience incentives from many stakeholders could make America's infrastructure resilient. (Image: public domain)

6. References Cited

Adams, I. (2015). *Before the Flood: Reducing Louisiana's Vulnerability to Severe Weather through Market-Based Insurance Reforms*. Pelican Institute for Public Policy, New Orleans LA. 8 p. https://www.rstreet.org/wp-content/uploads/2018/04/Before-the-Flood_Pelican_Final-1.pdf [accessed April 7, 2020]

Adams, I. (2018). *Insuring a Way Out: Modernizing the California Earthquake Authority*. Policy Study No. 32, R Street, Washington DC, 13 p. https://www.rstreet.org/2015/01/22/insuring-a-way-out-modernizing-the-california-earthquake-authorit/ [accessed April 5, 2020]

Alabama Secretary of State (2018). Act #2018-249, http://arc-sos.state.al.us/PAC/SOSACPDF.001/A0012524.PDF [accessed April 5, 2020]

Applied Technology Council (2009). *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco Earthquake Safety for Soft-Story Buildings*. ATC 52-3. Redwood City, CA, 60 p. https://sfgov.org/esip/sites/default/files/FileCenter/Documents/9756-atc523.pdf [accessed April 7, 2020]

Association of Bay Area Governments (2016). *Standard Plan Set for Residential Seismic Retrofitting*. San Francisco, CA http://resilience.abag.ca.gov/residents/planset/ [accessed April 6, 2020]

Awondo, S., Hollans, H., Powell, L., and Wade, C. (2016). *Estimating the Effect of FORIFED Home Construction on Home Resale Value*. University of Alabama, 6 p.

Barrer, P. (2018). *Newton Adopts Guidelines for Sustainable Construction*. Green Newton, Newton MA, https://www.greennewton.org/newton-adopts-guidelines-sustainable-construction/ [accessed May 19, 2020]

Bouwer, L.M. (2011). Have disaster losses increased due to anthropogenic climate change. *Bulletin of the American Meteorological Society*, 92(1):39-46.

California Earthquake Authority (2020). *How to Qualify for an Earthquake Insurance Premium Discount*. Sacramento, CA https://www.earthquakeauthority.com/California-Earthquake-Insurance-Policies/Earthquake-Insurance-Policy-Premium-Discounts [accessed May 19, 2020]

California Energy Commission (2020). *Energy Conservation Assistance Act*. https://www.energy.ca.gov/programs-and-topics/programs/energy-conservation-assistance-act [accessed April 6, 2020]

City of Berkeley (2019). *Seismic Retrofit Program & Refund Guidelines*. Berkeley, California, 2 p. https://www.cityofberkeley.info/uploadedFiles/Finance/Home/Files/Seismic%20Refund%20Program%20Guidelines.pdf [accessed April 6, 2020]

Connecticut Green Bank (2020). *Home Page*. Rocky Hill, CT https://ctgreenbank.com [accessed May 19, 2020]

Cox, S.R., Boothby, T., and Gravier, A. (2012). Increasing community resilience by integrating hazard mitigation into local comprehensive planning efforts. *2012 Alaska Planning Conference, Anchorage, Alaska, November 13, 2012*, 52 p. https://www.commerce.alaska.gov/web/Portals/4/pub/AK_APA_Haz-Mit_Comp-Plan.pdf [accessed April 7, 2020]

Daniel, C. (2015). *Replace the Residential and Commercial Energy Conservation Ordinances (RECO and CECO) with the Building Energy Saving Ordinance*. City of Berkeley Office of the City Manager, Berkeley CA, 14 p. https://www.berkeleyside.com/wp-content/uploads/2015/02/2015-02-24-Item-25-Replace-the-Residential.pdf [accessed April 7, 2020]

Enterprise Community Partners, Inc. (2015). *Ready to Respond: Strategies for Multifamily Building Resilience*. New York, NY 144 p. https://www.enterprisecommunity.org/download?fid=2154&nid=4325 [accessed May 18, 2020]

EERI Northern California Chapter (2020). *Homeowner Seismic Retrofit Incentive Program*. http://www.eerinc.org/?page_id=232 [accessed April 6, 2020]

EPA (2019). *Summary of the Energy Policy Act*. https://www.epa.gov/laws-regulations/summary-energy-policy-act [accessed April 6, 2020]

EPA (2020). *The Clean Water State Revolving Fund*. https://www.epa.gov/cwsrf [accessed April 6, 2020]

Federal Emergency Management Agency (2020). *Building Resilient Infrastructure and Communities (BRIC)*. Washington, DC https://www.fema.gov/bric [accessed April 6, 2020]

Florida Commission on Hurricane Loss Projection Methodology (2010). *Windstorm Mitigation Discounts Report*. Tallahassee, FL, 39 p. https://www.sbafla.com/method/Portals/Methodology/WindstormMitigationCommittee/2010/20100201_MitigationDiscountReport.pdf [accessed April 7, 2020]

Florida Office of Insurance Regulation (2005). Premium Discounts for Hurricane Loss Mitigation. Informational Memorandum OIR-05-22M, December 8, 2005, Tallahassee, FL https://www.floir.com/siteDocuments/OIR-05-022M.pdf [accessed May 19, 2020]

Florida Office of Insurance Regulation (2009). Mitigation Discounts, Summary for the Florida Commission on Hurricane Loss Projection Methodology. Tallahassee, FL, August 12, 2009

Florida State University (2010). *Hurricane Mitigation Inspection System Study*. DFS CS FRP 09/10-10. Florida State University College of Business Catastrophic Storm Risk Management Center, Tallahassee, FL, 55 p. https://stormrisk.org/sites/default/files/MSFH%20Hurricane%20Mitigation%20Inspection%20Study%20FINAL%20REPORT.pdf [accessed April 7, 2020]

Höppe P., and Grimm, T. (2008). Rising natural catastrophe losses–what is the role of climate change? Hansjürgens B., Antes R. (eds), *Economics and Management of Climate Change*, p. 13-22. Springer, New York, NY.

Marshall, S., and McCormick, K. (2015). *Returns on Resilience the Business Case*. Urban Land Institute Center for Sustainability. 52 p. https://uli.org/wp-content/uploads/ULI-Documents/Returns-on-Resilience-The-Business-Case.pdf [accessed April 3, 2020]

McEwen, B. and Miller, J. (2018). *Local Governments' Role in Energy Project Financing: A Guide to Financing Tools for the Commercial Real Estate Sector*. Institute for Market Transformation, Washington, DC, 40 p. https://www.imt.org/wp-content/uploads/2018/10/Local-Governments-Role-in-Energy-Project-Financing.pdf [accessed April 6, 2020]

Multi-Hazard Mitigation Council (2019). *Natural Hazard Mitigation Saves: 2019 Report*. Principal Investigator Porter, K.; Co-Principal Investigators Dash, N., Huyck, C., Santos, J., Scawthorn, C.; Investigators: Eguchi, M., Eguchi, R., Ghosh., S., Isteita, M., Mickey, K., Rashed, T., Reeder, A.; Schneider, P.; and Yuan, J., Directors, MMC. Investigator Intern: Cohen-Porter, A. National Institute of Building Sciences. Washington, DC, 619 p. www.nibs.org

National Association of Realtors (2020). How long do homeowners stay in their homes? https://www.nar.realtor/blogs/economists-outlook/how-long-do-homeowners-stay-in-their-homes [accessed June 23, 2020]

National Flood Insurance Program (2020) National Flood Insurance Program Community Rating System https://www.fema.gov/national-flood-insurance-program-community-rating-system [accessed May 19, 2020]

National Institute of Building Sciences (2015). *Developing Pre-Disaster Resilience Based on Public and Private Incentivization*. Washington DC, 62 p. https://www.nibs.org/page/mmc_projects [accessed March 29, 2020]

National Institute of Building Sciences (2016). *An Addendum to the White Paper for Developing Pre-Disaster Resilience Based on Public and Private Incentivization*. Washington DC, 40 p. https://www.nibs.org/page/mmc_projects [accessed March 29, 2020]

National Oceanic and Atmospheric Administration (2020). *U.S. Billion-Dollar Weather and Climate Disasters*. National Centers for Environmental Information, https://www.ncdc.noaa.gov/billions/, DOI: 10.25921/stkw-7w73 [accessed March 30, 2020]

OECD (2019). *Revenue Statistics 2019 - the United States*. 2 p. https://www.oecd.org/tax/tax-policy/revenue-statistics-united-states.pdf [accessed April 6, 2020]

Perlman, E. (2018). What is the Ideal Hold Period for A Multifamily Deal? Medium. Retrieved from https://medium.com/datadriveninvestor/what-is-the-ideal-hold-period-for-a-multifamily-deal-c3f53da126e1 [accessed June 23, 2020]

Porter, K., and Yuan, J.Q. (2020). America's Growing Disaster Liability. Working Paper 2020-01, SPA Risk LLC, Denver CO, https://www.sparisk.com/pubs/Porter-Yuan-2020-Disaster-Liability.pdf

Rainwater, B. (2007). *Local Leaders in Sustainability, A Study of Green Building Programs in Our Nation's Communities*. American Institute of Architects, Washington, DC, 56 p. http://www3.cec.org/islandora-gb/en/islandora/object/islandora%3A996/datastream/OBJ-EN/view [accessed April 7, 2020]

Rollins, J. (2013). *Improving Wind Mitigation Incentives*. Air Currents, AIR Worldwide, August 2013.

San Francisco Department of Building Inspection (2010). Soft Story Wood Frame Building Voluntary Seismic Retrofitting Ordinance No.54-10 Effective April 19, 2010 Frequently Asked Questions. San Francisco CA, 3 p. https://sfdbi.org//sites/default/files/Documents/Permit_Review_Services/Soft_Story_Wood_Frame_Buildings/Soft_Story_FAQ.pdf [accessed April 7, 2020]

San Francisco Department of Building Inspection (ND). *Soft Story FAQ*. San Francisco, CA, https://sfdbi.org/soft-story-faq [accessed April 7, 2020]

Simmons, K.M., Kovacs, P., and Smith, A.B. (2020). State-by-state analysis of benefits to cost from wind-enhanced building codes. *Natural Hazards Review* 21(2): 04020007, 10 p.

Smith, A.B., and Katz, R.W. (2013). US billion-dollar weather and climate disasters: data sources, trends, accuracy, and biases. *Natural Hazards* 67: 387–410. https://doi.org/10.1007/s11069-013-0566-5 [accessed March 30, 2020]

South Carolina Department of Insurance (2015). *Status of the South Carolina Coastal Property Insurance Market, Status Report for 2014*. Columbia, SC, 43 p. https://www.scstatehouse.gov/reports/DeptOfInsurance/2014CoastalReportFINAL.pdf [accessed April 7, 2020]

U.S. Census Bureau (2018). *Monthly Construction Spending, January 2018. Release Number CB18-29*. https://www.census.gov/construction/c30/pdf/pr201801.pdf [accessed March 29, 2019]

U.S. Census Bureau (2019). *Annual Characteristics of New Housing*. https://www.census.gov/construction/chars/ [accessed April 5, 2020]

U.S. Census Bureau (2020). *National Population Totals and Components of Change: 2010-2019*. https://www.census.gov/data/tables/time-series/demo/popest/2010s-national-total.html [accessed March 29, 2020]

U.S. Department of Energy (2018). *Commercial PACE Financing for Resiliency*. 3 p. https://betterbuildingssolutioncenter.energy.gov/toolkits/commercial-pace-financing-resiliency [accessed April 5, 2020]

U.S. Government Accountability Office (2015). *Preparing for Climate-Related Risks: Lessons from the Private Sector*. GAO-16-126SP, 44 p., https://www.gao.gov/assets/680/673772.pdf [accessed April 3, 2020]

U.S. Government Printing Office (2016). Controlling the rising cost of federal responses to disaster. (114-40) Hearing Before the Subcommittee on Economic Development, Public Buildings, and Emergency Management of the Committee on Transportation and Infrastructure House of Representatives One Hundred Fourteenth Congress Second Session May 12, 2016, https://www.govinfo.gov/content/pkg/CHRG-114hhrg20214/html/CHRG-114hhrg20214.htm [accessed April 3, 2020]

Yun, L. (2016). Four more years? No quick end in sight for the U.S. housing shortage. *Forbes.com*, December 13, 2016, https://www.forbes.com/sites/lawrenceyun/2016/12/13/housing-shortage-for-how-long/#6b6975335ee4 [accessed March 29, 2020]