The Future of

HOUSING

ImpactMap

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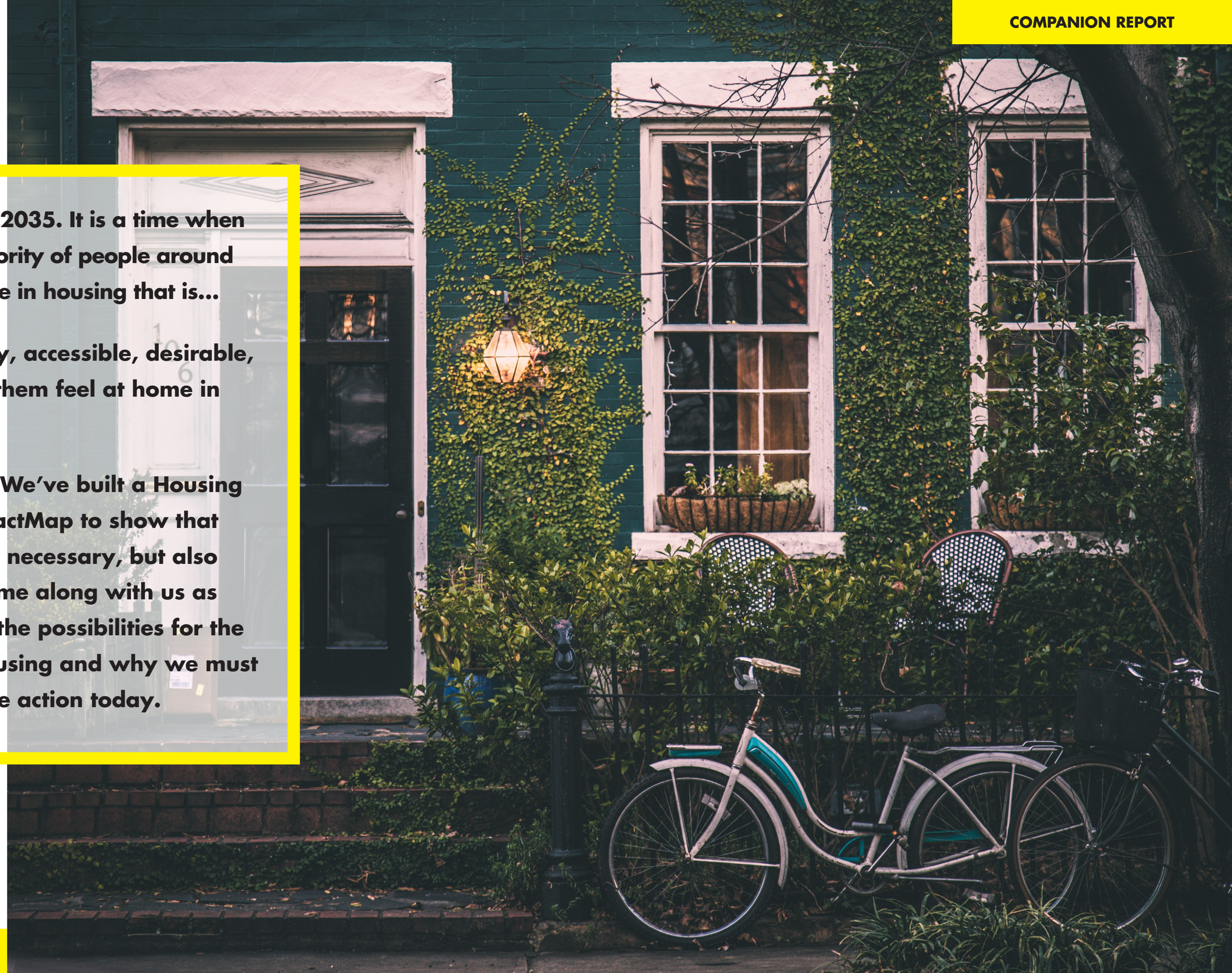
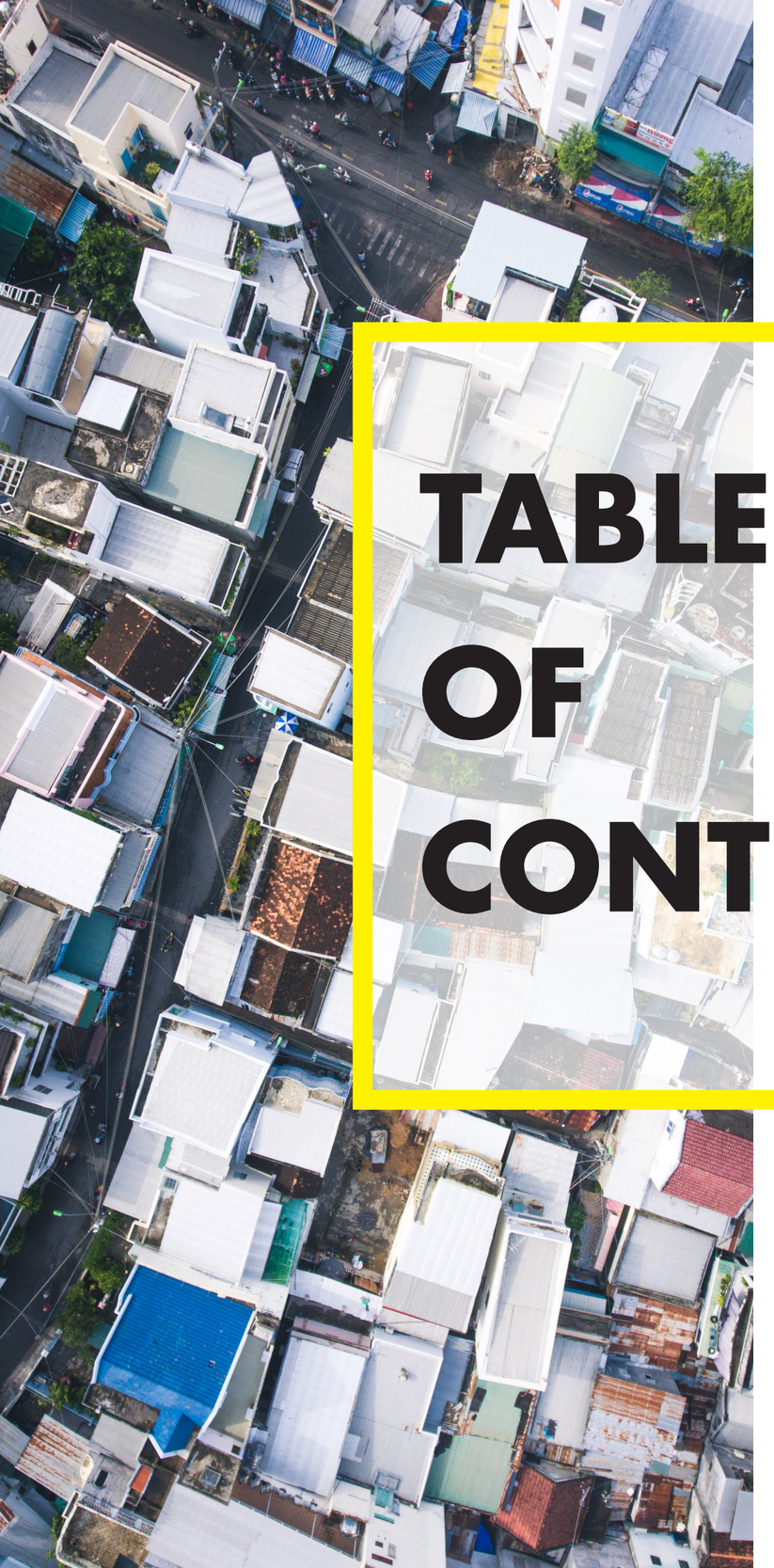
COMPANION REPORT



Imagine it is 2035. It is a time when the vast majority of people around the world live in housing that is...

Safe, healthy, accessible, desirable, and makes them feel at home in the world.

Impossible? We've built a Housing Futures ImpactMap to show that it is not only necessary, but also possible. Come along with us as we explore the possibilities for the future of housing and why we must begin to take action today.



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INTRO-DUCTION

WHY AN IMPACTMAP?

A Futures ImpactMap is an analytical tool for understanding persistent problems and barriers that make up grand challenges in various domains, as well as the actions that key stakeholders can take to overcome them and achieve a preferred future state. Grand challenges comprise a combination of complex and overlapping social, technological, economic, environmental, and policy issues. A Futures ImpactMap will highlight the most effective actions to address these issues and accelerate progress toward a more positive future.

XPRIZE plans to use ImpactMaps to help identify potential XPRIZE competitions and other actions that can accelerate a bridge to abundance for all across domains including shelter and infrastructure; energy and resources; planet and environment; health and wellness; learning and human potential; civil society; and space and new frontiers.

Emerging, exponential technologies and other innovations in policy and financing have the potential to address grand challenges in these areas, but require new action by key stakeholders and innovators from around the globe.

METHODOLOGY & REPORT STRUCTURE

This report and the associated Housing Futures ImpactMap seeks to present a fresh point of view on the topic of housing with the purpose of inspiring innovative ideas and accelerating action toward a preferred future state. The report is not intended to be a comprehensive summary of all issues related to housing in every corner of the globe. Rather, we have sought to present our view on the most critical issues requiring new thinking, action, and breakthroughs.[1]

At the core of this report stands the primary research question: what are the potential moonshots that will promote safe, healthy, accessible, and desirable housing? To answer this question, we have identified three sub-questions that structured our research:

1. What are the main trends that shape today's global housing problems?

2. What are the key initiatives taken by both the public and private sectors, as well as NGOs, to cope with the global housing problem; and what are the emerging technologies in that context?

3. Based on trends, programs, and emerging technologies, what are the potential futures—desirable and undesirable alike—of global housing?

[1]Additional reference materials that provide a baseline understanding of the issues at stake and potential solutions already under discussion can be found in the Selected Bibliography

In order to answer the above-mentioned questions, our research was based on a three-pronged strategy. First, we conducted extensive secondary research, based on open-source databases and publications. Second, we conducted numerous interviews with experts from various fields, in which we not only asked for their opinion, but also asked them to support their arguments with evidence and data (that data was also incorporated into this study). Third, we tapped into the wisdom of the crowd: we created a community of experts, all collaborating in real time using the digital platform Floating Knowledge. By using this platform, we were able to present to the participants questions and analytic challenges, as well as review our own analysis.

The structure of the report reflects the primary and secondary research and analysis conducted by the XPRIZE Institute around existing challenges and key trends in housing; recommendations gathered at two interactive workshops with housing stakeholders; insights gained by tapping into our community of experts and by interviewing dozens of these experts; and ideas from XPRIZE on how stakeholders can work together to achieve a preferred future of housing, including potential XPRIZE competitions that can help address this grand challenge.

Explicitly throughout Parts I and II and implicitly in Parts III and IV of the report, the grand challenge, trends, projected future state, and preferred future state are organized according to six themes that we believe are critical to understanding the future of housing. These themes are: demographics, affordability, technology, adaptability, resilience, and environment.

In addition, the report references six user lenses, organized by economic circumstance and stage in life. These lenses are not mutually exclusive and do not necessarily address every individual or housing need across the globe. They are intended to encourage the reader to think about housing from the perspective of different people, in different places, at different stages of their lives. They are intended as a reminder that housing is not only about buildings or city planning or finance; housing is about people and the communities we all want to build. The six user lenses are:

BY ECONOMIC CIRCUMSTANCE:

- **Refugees and Slum-Dwellers:** Populations for whom temporary, informal, and substandard housing is at risk of becoming a permanent way of life.
- **The New Middle:** People for whom the gap between their income and the cost of housing is large or widening.
- **Affluent and Savvy:** This population represents the first adopters of new technology. In many cases, this group also supports the idea of housing as a means to accrue wealth and thus contributes to rising housing prices.

BY STAGE IN LIFE:

- **Young and Aspirational:** These young people are often more educated and more mobile than previous generations and increasingly make up the gig economy.
- **Multi-family or Multigenerational:** This includes households that have either dependent children or dependent adults, and in many cases, both.
- **Elderly and Infirm:** People ages 65 and above are included in this group. Much of this population remains healthy and active but it also includes those who need everyday support or significant long-term health care

Finally, throughout the report, you will see four types of boxes. These are meant to bring a human perspective to the issues and analysis, and inspire your own new ideas about the future of housing. These boxes are:

- **Information Boxes:** (gray) Provide additional analysis and anecdotes drawn from our research.
- **Quote Boxes:** (green) Highlight thoughts from individuals—some experts, some reflecting life experience—that embody or illuminate key concepts related to the future of housing.
- **Story Boxes:** Excerpts from short fiction that XPRIZE commissioned for the 2017 Visioneers Summit Future of Housing exhibit.
- **Audio/Video Boxes:** Highlight XPRIZE and third-party content that adds additional dimension to the issues discussed.

We encourage readers to use this report to begin or continue a conversation about the future of housing and to take action—in collaboration with XPRIZE, sponsor Lowe's, or independently—to help realize a better, more abundant future. Turn to Part I to begin your journey toward the future of housing.

BEING AWARE OF OUR OWN BIASES

No research is completely free of inherent biases, and this Futures ImpactMap and report are no different. Despite our efforts to diversify our perspective, we are aware of this report's somewhat Western-centric approach and of its strong focus on technological advances. The report presents a balanced problem-set, which addresses most user-lens problems. However, the report tends to focus on what we call "strong users," i.e., the new middle, affluent and savvy, and the young and aspirational. With regards to positive scenarios, the future looks more positive for the "strong users" than for the "weak users," i.e., refugees and slum-dwellers, and elderly and infirm.[2] Breakthroughs are also inclined to focus on the strong users and emphasize technological breakthroughs over other domains, such as policy and financing.

However, these biases also reflect our belief that technology has, by far, the most potential to solve the challenges presented in this report. We believe that other groups work and efforts (e.g., Sustainable Development Goals, International Rescue Committee, government investments, etc.) often address non-technological approaches to improving those futures. We also believe that although technological breakthroughs will inherently benefit the "strong users" first, these users will propel access to beneficial technological breakthroughs and have a trickle-down effect for the "weak users."

[2] Multifamily and Multigenerational could be either strong or weak, especially when dealing with millennials.

ABOUT XPRIZE

The XPRIZE Foundation is the world-leader in incentivized competitions to create breakthroughs that solve humanity's grandest challenges. XPRIZE believes in harnessing the power of the crowd and of exponential technologies in order to achieve a massive transformative purpose that builds a bridge to abundance for all.

The XPRIZE philosophy is that key innate human attributes—creativity, ingenuity, entrepreneurialism, and inventive spirit—are inherent in every individual throughout the world. By working together as a global community, we can solve any grand challenge. This is especially true thanks to the ever-empowering toolset of emerging technologies, once only accessible to big business and government, that are becoming more available to individuals. This leads to the democratization of problem-solving. XPRIZE designs an intricate instrument to tap into that global crowd to source moonshot solutions in hopes of accelerating the pace for desperately needed innovative inventions and make them readily available to humanity as a whole.

An XPRIZE is a highly leveraged incentivized prize competition designed to solve the world's greatest challenges. An XPRIZE puts a target on the back of a challenge and asks anyone in the world to solve it. Whoever hits the target, wins. But determining an XPRIZE requires significant research, landscape assessment, and design. An XPRIZE must catalyze moonshot problem-solving to address the grandest challenges facing humanity, produce exponential impact, generate exponential economics, address a challenge that will not be solved by traditional problem-solvers and problem-solving mechanisms, and ignite a critical mass of rapid experimentation from a diverse crowd.

XPRIZE only launches the most impactful prizes, those that are going to achieve a moonshot. To identify the most transformative moonshots, XPRIZE begins by developing a Futures ImpactMap that charts the full landscape of the present state, what needs to change, and which massive breakthroughs would not happen unless the crowd was incentivized to develop radical innovations. Once we know which moonshots will not be achieved by traditional actors alone, XPRIZE sources brilliant visioneers in the crowd to vet and evaluate which moonshots really should become the next XPRIZE.

ABOUT LOWE'S

Lowe's Companies, Inc. (NYSE: LOW) is a FORTUNE® 50 home improvement company serving more than 18 million customers a week in the United States, Canada, and Mexico. With fiscal year 2017 sales of $68.6 billion, Lowe's and its related businesses operate or service more than 2,390 home improvement and hardware stores and employ over 310,000 people. Founded in 1946 and based in Mooresville, N.C., Lowe's supports the communities it serves through programs that focus on K-12 public education and community improvement projects. For more information, visit Lowes.com.

PART I: HOUSING TODAY

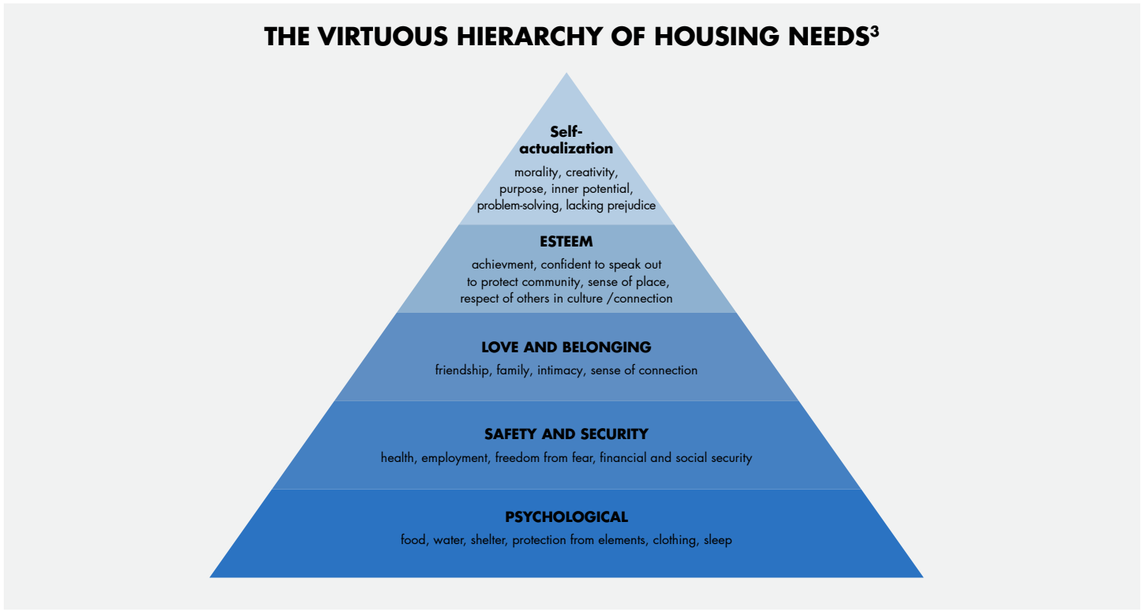
WHY HOUSING MATTERS

Housing is one of our fundamental needs for survival. Not only does housing provide physiological needs like providing warmth and safety from natural elements, it is also crucial to our psychological and emotional needs. Housing is inextricably linked to culture, personal identity, and our desire to find our home in the world (see Figure 1 below).

The world we live in today is in a critical time for housing. The United Nations (U.N.) has defined seven basic principles of adequate housing (see Information Box). We are already in danger of failing to meet these principles for a growing number of people around the globe.

Population growth and rapid urbanization threaten our ability to provide housing that meets basic physiological needs. Demographic shifts and a widening economic divide threaten our ability to provide housing that meets psychological needs. New technologies, and how we respond to them, are changing at an exponential pace. We believe that without new breakthroughs in technology and innovation, business and markets, and policy and regulation, the gap between the housing needs of humanity and the available housing solutions will only increase. However, we also believe a future is possible where most, if not all, people have access to housing that is not only adequate but safe, healthy, accessible, and desirable. To achieve this, housing must evolve in ways that are faster or, in some cases, different from the current trajectory.

FIGURE 1: HIERARCHY OF HOUSING NEEDS



[3] Jennifer Dean, "Room for All," Alternatives Journal, September 2016, http://www.alternativesjournal.ca/room-all-simple-ways-accessible-adequate-housing-builds-best-communities..

U.N. SEVEN BASIC PRINCIPLES OF ADEQUATE HOUSING[4]

- Security of tenure: housing is not adequate if its occupants do not have a degree of tenure security, which guarantees legal protection against forced evictions, harassment, and other threats.
- Availability of services, materials, facilities, and infrastructure: housing is not adequate if its occupants do not have safe drinking water, adequate sanitation, energy for cooking, heating, lighting, food storage, or refuse disposal.
- Affordability: housing is not adequate if its cost threatens or compromises the occupants' enjoyment of other human rights.
- Habitability: housing is not adequate if it does not guarantee physical safety or provide adequate space, as well as protection against the cold, damp, heat, rain, wind, other threats to health, and structural hazards.
- Accessibility: housing is not adequate if the specific needs of disadvantaged and marginalized groups are not taken into account.
- Location: housing is not adequate if it is cut off from employment opportunities, health care services, schools, childcare centers, and other social facilities, or if it is located in polluted or dangerous areas.
- Cultural adequacy: housing is not adequate if it does not respect and take into account the expression of cultural identity.

STATE OF HOUSING TODAY

STORY

"'Can I help you?' I went on auto-pilot, running through requests as quickly as I could, freeing my mind to fret about the dinner to come. Fifty people! That was how many lived in this joint household, according to Jenny. Seventeen small houses circling a central communal home, with a big kitchen, game room, movie center, pool – plenty of shared resources, which was good for the planet. It had been ridiculous, I had to admit, all those decades of American nuclear families insisting on their own separate kitchens. What a waste! And I'd never be able to afford a house with a pool on my own."

—Excerpted from "Hearth" by Mary Ann Mohan

GRAND CHALLENGE STATEMENT

Desirable attributes of a home vary widely across geographies and cultures. Still, there are broadly applicable grand challenges regarding housing that impact all humans, regardless of location, societal norms, or economic status.

At the most fundamental level, there is an increasingly stark imbalance between housing as a basic human need and housing as an asset to be bought and sold. There are also many promising experiments in innovative housing—in architecture, materials, finance, planning, policy, and technology integration—and yet, few have emerged as models that have a proven ability to benefit millions or billions of people. Finally, when reviewing a broad swath of literature about housing, it is easy to focus on the physical infrastructure and the regulations that drive its development. Most reports, analysis, and data do just that. But housing at its core is about who is housed; it is about people, and their desire to feel at home.

Our analysis and the ideas in this report and our Housing Futures ImpactMap are designed around these aspects of the grand challenge, and ask readers to consider how we can scale and replicate the best solutions to meet the world's housing needs, both fundamental and desirable, while ensuring people remain where they belong, at the center of the issue.

SIX PROBLEMS IN THE GRAND CHALLENGE FOR HOUSING

We have identified six problems that comprise the grand challenge for housing.

DEMOGRAPHICS:

As we are heading toward two-thirds of the world's population living in cities, there is a tremendous pressure on the housing market to keep up with housing demand. Certain cities in the Global South, as well as developing countries in Asia, are facing additional negative externalities associated with the extremely rapid urbanization.

AFFORDABILITY:

The relative cost of housing in people's lives, as well as the stock of affordable housing available and being built, is vastly insufficient to address the increasing population of both the developing and developed world. Between better policy and new financing solutions, serious attention needs to be put toward this challenge area.

[4] "The Right to Adequate Housing," Office of the United Nations High Commissioner for Human Rights, 2009, http://www.ohchr.org/Documents/Publications/FS21_rev_1_Housing_en.pdf.

TECHNOLOGY:

Emerging technologies offer the potential to radically improve the cost of building, the environmental efficiency of building, as well as the function and experience of a home. These technologies range from smart building technologies, the IoT, artificial intelligence (AI), synthetic biology, and biomimicry—we need to integrate these solutions at scale, faster, everywhere.

ADAPTABILITY:

Housing has traditionally been a lifetime asset with increased mobility, lifestyle changes, an aging population, demographic explosion, etc. We have to start adapting housing stock to meet our needs rather than our societies adapting to the housing stock. This is true both for existing housing and new builds.

RESILIENCE:

There is a growing understanding of the consequence of climate change and the need for better built environment resilience strategies. However, the responses currently underway are insufficient in scope and pace.

ENVIRONMENT:

Building homes is one of the most natural resource-intensive human activities. Additionally, construction waste and the weight of urban life on natural habitats is severely damaging the health of ecosystems and their ability to recover.

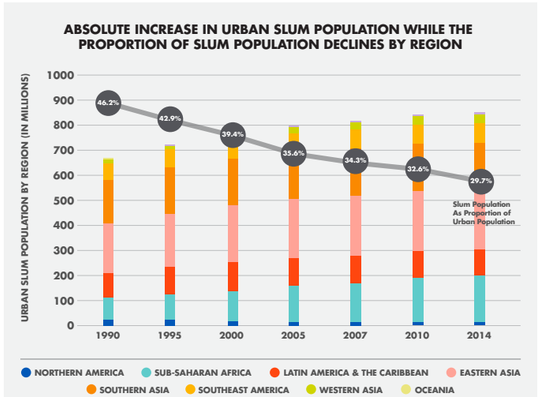
Each of these problems is explained in greater detail below. Each also includes a snapshot that details how these problems are affecting real people—young and aspirational, multifamily and multigenerational, elderly and infirm, refugees and slum dwellers, the new middle, and affluent and savvy—in communities across geographies and cultures.

DEMOGRAPHICS

Locations globally where population growth is increasing most rapidly are not keeping up with housing demand and face additional negative externalities associated with rapid urbanization.

Today, about one-third of the urban population in the Global South, defined as developing countries primarily in the Southern hemisphere, live in informal housing or slums. These homes are characterized by insecurity of tenure and a low standard of infrastructure and services.[5,6] Informal housing also often lacks access to basic services such as electricity, clean water, and sanitation. Although the proportion of people living in slums is declining, the absolute number of people in slums continues to rise (see Figure 2).

FIGURE 2: TRENDS IN URBAN SLUM POPULATIONS BY REGION[13]



As urbanization intensifies in Asia and Africa, and cities struggle to serve even larger populations, the challenge of providing adequate housing will only worsen. Analysts estimate that the affordable housing gap for urban households will grow from 330 million households in 2017 to 440 million households (1.6 billion people) by 2025, more than a 30 percent increase.[7]

Current housing stock cannot absorb the high birth rates and rapid urbanization in many locations. High costs, an overemphasis on home ownership, and inappropriate government policies and laws are some of the primary contributors to this gap in adequate, secure, and affordable housing supply that has plagued emerging megacities around the globe.[8,9] Nigeria, for example, has a housing shortage estimated at 17 million units, which is estimated to require more than $360 billion in new funding.[10]

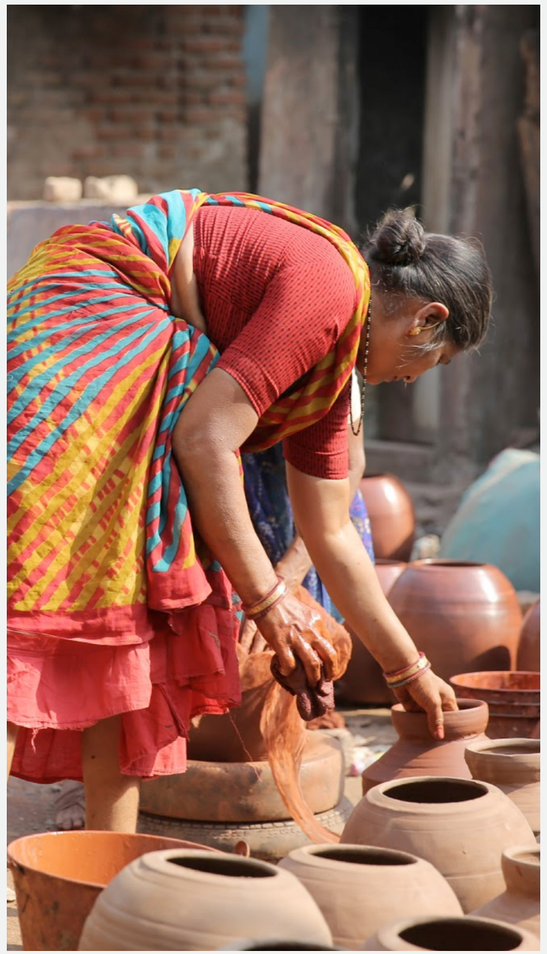
For the past 30 years, policymakers at national and international levels have believed that the private sector would help solve this problem by building the right housing in the right place when given access to liquid capital and reduced regulation. That belief has proved mostly unfounded.[11] Instead, the world has seen a shortage of affordable and adequate housing options for low-income households and a concentration of construction activity in high-end housing, often with high vacancy rates. This has often led to sprawling low-density developments and unplanned neighborhoods that are not integrated into transportation networks or near livelihood options.

In addition to a gap in housing, rapid population growth and urbanization lead to additional problems including traffic congestion, water-borne or other contagious diseases, and higher crime levels. Solutions to these issues require wealth, good government, or both, and developing world mega-cities often have neither.[12]

[5] Robin King, Mariana Orloff, Tejas Pande, and Terra Virsilas, "Confronting the Urban Housing Crisis in the Global South: Adequate, Secure, and Affordable Housing," World Resources Institute, (2017), https://www.wri.org/sites/default/files/towards-more-equal-city-confronting-urban-housing-crisis-global-south.pdf.
[6] Reazul Ahsan, J.M.Quamruzzaman, "Informal Housing and Approaches towards the Low-income Society in Developing Countries," (University of South Australia, accessed December 13, 2017), http://search.ror.unisa.edu.au/media/researcharchive/open/9915910952001831/53108992580001831.
[7] King, "Confronting."
[8] "Africa Looks to Solve Housing Shortage Amid Growing Population," Oxford Business Group, accessed December 12, 2017, https://www.oxfordbusinessgroup.com/analysis/no-place-home-growing-population-continent-looks-solve-its-housing-shortage.
[9] King, "Confronting," 20.
[10] "Affordable Housing in Africa," International Finance Committee, accessed December 12, 2017, http://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/trp_featurestory_africahousing.
[11] S. Hamman, "Housing Matters," in The Urban Imperative: Towards Competitive Cities, ed. A. Joshi-Ghani, E. Glaeser (New Delhi: Oxford University Press, 2015), 336–337.
[12] Edward L. Glaeser, "A World of Cities: The Causes and Consequences of Urbanization in Poorer Countries," Journal of the European Economic Association12, no. 5 (2014): 1154-1199. http://www.nber.org/papers/w19745.pdf; Richard Florida, "Why So Many Emerging Megacities Remain So Poor," Citylab, January 16, 2014, https://www.citylab.com/life/2014/01/why-so-many-mega-cities-remain-so-poor/8083/.
[12] King, "Confronting," 2.

The following system failures are key contributors to this problem:

- Political volatility and corruption make government-supported solutions challenging to design and implement.[14]
- A large portion of developers and investors in the Global South are focused on the top end of the market. Private capital is rarely directed towards the mass housing market and usually focuses on the commercial real estate segment, where there is often less risk and a higher return on investment.[15]
- Housing faces a significant financing gap for individuals in much of the developing world where millions of people lack access to basic financial tools such as credit, savings, and insurance.[16] This gap is often the most extreme in the places with the most severe housing shortages. In these places, housing continues to be built informally.[17]



SNAPSHOT FROM THE CURRENT STATE: THE PROMISE OF A SLUM

KEY USER LENS:

- **Refugees and Slum Dwellers**
- **Young and Aspirational**
- **Multigenerational/Multifamily**

Dense cultural center. Hub of innovation. Billion dollar business center. Slum.

These are all words that characterize the buzzing cultural center that is the Dharavi slum, the largest in Mumbai, India, and the second largest in Asia. It is estimated that one million people inhabit the 557 acres that make up Dharavi, where population density ranges form 600 to 2,000 people per acre.[18] A city within a city, Dharavi is one unending stretch of narrow muddy lanes, open sewers, and small shacks, where most of its inhabitants survive on less than $1 per day.

The vast majority of residential structures that serve as homes in this sub-standard metropolis are densely packed conglomerates of corrugated tin and mudbrick, with little more than four walls and a roof. They do not have kitchens, living rooms, or toilets; in fact the slum averages one toilet per 1,400 people.[19] In the rainy season, streets lacking drainage become canals of human waste. Beyond these streets are the cramped tenements where, for water, residents make do with rusting pipes, leaking taps, and badly corroded storage tanks. Typically, 15 families share one tap that often only works for two hours a day.[20]

On the surface, Dharavi is a public health disaster, a place where only the poorest and most pitiable members of society reside. But amidst this poverty, ingenuity and innovation bolster one of the most vibrant economies in the world. Dharavi is home to approximately 5,000 businesses and 15,000 single-room factories with an estimated annual business turnover valued at over $1 billion. From the busy garment and jewelry manufacturers to recycling units specializing in plastic waste, Dharavi is filled with makers and doers who have managed to innovate despite their circumstances.

Imagine what the people of Dharavi and millions of others in slums across the globe could accomplish with even marginally better housing and basic services. Imagine how they could change the world with better tools and better homes.

AFFORDABILITY

There is a growing imbalance between the most logical policies to make housing more affordable and policies designed to support a system that seeks to increase the price of housing by either limiting supply or leveraged financing.

Housing plays a central role in national, regional, local, and personal economies. In the United States, residential housing makes up 20 percent of its gross domestic product (GDP).[22] Housing construction alone contributes $1.2 trillion to the nation's economic output and is estimated to represent a third of the wealth held by the nonfinancial private sector.[23] In Europe, the total value of residential housing exceeds €24 trillion.[24] Around the world, the majority of households tend to hold wealth in the form of homes instead of financial assets. In France, for example, less than 25 percent of households own stocks but nearly 60 percent are homeowners.[25] Since the 1970s, the cost of construction has remained broadly

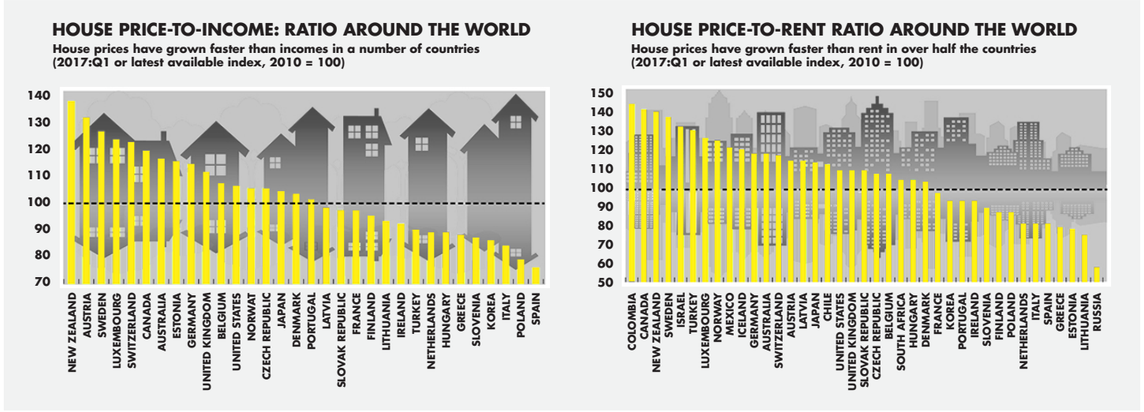
[14] Glaeser, "A World Of Cities," 1154-1199.: "Challenges and the Way Forward in the Urban Sector," Sustainable Development in the 21st Century, accessed December 2017, https://sustainabledevelopment.un.org/content/documents/challenges_and_way_forward_in_the_urban_sector_web.pdf.
[15] Oxford Business Group, "Africa."
[16] "Financial Inclusion," The World Bank, last modified April 5, 2017, http://www.worldbank.org/en/topic/financialinclusion/overview.
[17] Florida, "Solving."
[18] "Mumbai Population 2017," World Population Review, accessed December 12, 2017, http://worldpopulationreview.com/world-cities/mumbai-population/.; Clara Lewisl, "Dharavi Is no Longer Asia's Largest Slum," Times of India, July 6, 2011, http://timesofindia.indiatimes.com/india/Dharavi-in-Mumbai-is-no-longer-Asias-largest-slum/articleshow/9119450.cms.
[19] Kevin Watkins, "Human Development Report 2006," United Nations Development Programme, (New York: United Nations Development Programme, 2006), 37, http://hdr.undp.org/sites/default/files/reports/267/hdr06-complete.pdf.
[20] Watkins, "Human," 37.
[21] Vidhisha Mahesh, "Asia's Biggest Slum, Or A Billion Dollar Industry?" Affinity Magazine, May 6, 2017, http://affinitymagazine.us/2017/05/06/asias-biggest-slum-or-a-billion-dollar-industry/.
[22] "Why Housing Is Important to the Economy," Independence Title, August 1, 2014, http://independencetitle.com/why-housing-is-important-to-the-economy/.
[23] Kimberly Amadeo, "How Does Real Estate Affect the U.S. Economy?" The Balance, October 28, 2017, https://www.thebalance.com/how-does-real-estate-affect-the-u-s-economy-3306018.
[24] "Housing Europe Supports the Joint Letter to the European Commission," Housing Europe, April 1, 2015, http://www.housingeurope.eu/resource-461/a-new-start-for-the-real-estate-sector.; "The State of the House Price Cycle in the Euro Area," European Central Bank Economic Bulletin, issue 6 (2015), https://www.ecb.europa.eu/pub/pdf/other/eb201506_article01.en.pdf.
[25] Min Zhu, "Housing Markets, Financial Stability, and the Economy," International Monetary Fund, June 11, 2014, https://www.imf.org/en/News/Articles/2015/09/28/04/53/sp060514.

stable, however, housing prices have surged. The increased cost of housing can be largely attributed to increases in the cost of land. In developed countries, there appears to be a strong correlation between regulatory regimes that restrict land use and the supply of new homes. In major urban markets in the U.S., for example, the impact of land use regulations have increased housing prices between an estimated 23 percent (in Boston) and 50 percent (in Manhattan).[26]

Housing not only satisfies an essential need but also serves as the central investment for many households. Once individuals become homeowners themselves, they have a vested interest in supporting policies that protect and promote housing as an investment. Along with homeowners, investors, financial institutions, and many policymakers also have incentives to see housing prices continue to increase.[27]These incentives ultimately lead to an economic system in which housing prices grow at rates faster than the incomes of the vast majority of occupants (see Figure 3).[28]

This prevents some of the most logical policies to make housing more affordable from being put into place. Rather than increasing the supply of housing to lower prices, policy is designed to do just the opposite, and keep prices high through limited supply and zoning laws or leveraged financing, which attempts to satisfy demand by increasing affordability without lowering prices.

FIGURE 3: GROWTH OF HOUSING PRICES GLOBALLY



The following system failures are key contributors to this problem:

- There is a fundamental disconnect between policies that seek to make housing more affordable by increasing supply and thus lowering prices, and policies that seek to prop up prices of housing as a financial asset.
- The tie between land prices and housing prices appears to drive the rising price of housing. Land use and ownership is key to affordable housing, but land costs account for 40-80 percent of property costs. A McKinsey Global Institute analysis found that urban land markets do not follow normal supply and demand due to fragmented or public ownership, poor land records, and regulations and zoning laws that discourage development.[32]
- The idea that homeownership should remain a key financial asset and an aspiration for the majority of individuals and families remains mostly unquestioned. Many governments continue to provide tax benefits and other incentives that encourage home ownership without fundamentally re-evaluating whether this is a positive social or financial policy.[33]
- The increasing "financialization" of the economy works to the advantage of the wealthiest, who benefit from the financial and transactional systems that subsequently underwrite housing prices. This, in turn, accelerates wealth stratification and social discord.[35]

SNAPSHOT FROM THE CURRENT STATE: THE PROMISE OF A SLUM

KEY USER LENS:

- The New Middle
- Savvy and Affluent

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY

- Novel methods to dispose and utilize waste to create building materials
- Methods of turning recycled plastics etc. into sustainable building materials that are strong, cheap, and lightweight
- Blockchain technologies for land titling

Rising rents and a decreasing supply of affordable housing stock are making major cities across the globe unaffordable to not only low-income residents, but also an increasing portion of the middle class. Real estate speculation and foreign investment are major drivers of these trends.

In nearly every major city today, foreign investors are seeking properties that they have

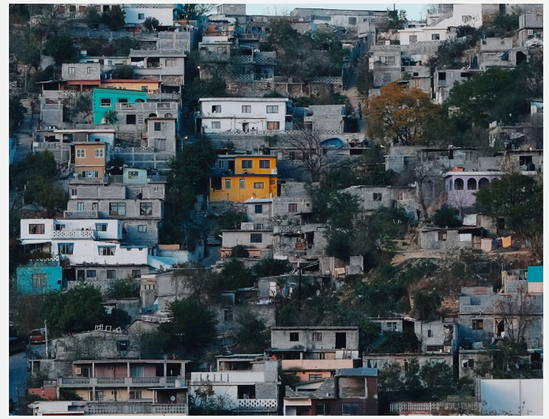
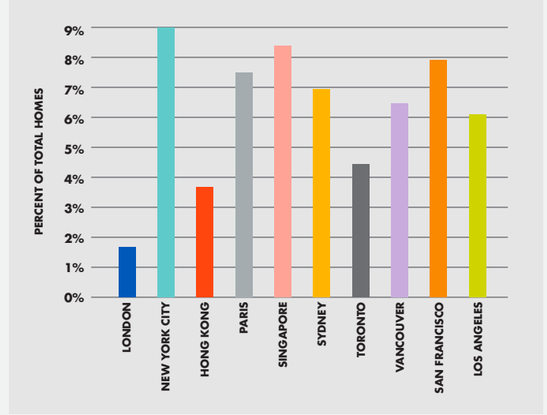


FIGURE 4: VACANCY AS A PERCENTAGE OF HOMES IN SELECTED CITIES



[26] Katharina Knoll, Moritz Schularick, and Thomas Steger, "No Price Like Home: Global House Prices, 1870 – 2012," accessed December 12, 2017, 43, http://piketty.pse.ens.fr/files/Schularicketal2014.pdf.
[27] Zhu, "Housing."
[28] "Housing and the Economy: Policies for Renovation," Economic Policy Reforms Going for Growth, 2011, https://www.oecd.org/newsroom/46917384.pdf.
[29] "Global Housing Watch," International Monetary Fund, September 12, 2017, http://www.imf.org/external/research/housing/.
[30] Knoll, "No Price."
[31] Stephen Punwasi, "Vacant Homes Are A Global Epidemic, And Paris Is Fighting It With A 60% Tax," Better Dwelling, March 2, 2017, https://betterdwelling.com/vacant-homes-global-epidemic-paris-fighting-60-tax/.
[32] Nicklas Garemo, Jan Mischke, Sangeeth Ram, Shirish Sankhe, and Jonathan Woetzel, "Tackling the world's affordable housing challenge," McKinsey Global Institute, October, 2014, https://www.mckinsey.com/global-themes/urbanization/tackling-the-worlds-affordable-housing-challenge
[33] Daniel Indiviglio, "Should the Government Encourage Home Ownership?" The Atlantic, June 17, 2010, https://www.theatlantic.com/business/archive/2010/06/should-the-government-encourage-home-ownership/58320/; Andrew Henderson, "Why Buying a House Is a Bad Investment," Nomad Capitalist, accessed December 12, 2017, http://nomadcapitalist.com/2016/10/14/buying-a-house-bad-investment/.; Kevin Mercandante, "The Truth? Your House Is Not An Investment," Money Under 30, March 13, 2017, https://www.moneyunder30.com/why-your-house-is-not-an-investment.
[34] Bruce Bartlett, "'Financialization' as a Cause of Economic Malaise," The New York Times, June 11, 2013, https://economix.blogs.nytimes.com/2013/06/11/financialization-as-a-cause-of-economic-malaise/.
[35] Bartlett, "'Financialization.'"
[36] Punwasi, "Vacant."

no intention of ever living in, but rather wish to use to hold surplus capital in places with rapidly increasing land values. These vacant properties have created artificial housing shortages while also inflating real estate prices for other potential residents. In several major cities, vacant properties make up nearly 10 percent of the housing stock (see Figure 4).

Cities like Paris and Vancouver (along with Sydney, Singapore, Hong Kong, and Toronto) have developed aggressive affordable housing plans that seek to rebalance access to housing.

In Paris, there are currently more than 100,000 empty homes, representing 7.5 percent of all residential dwellings in the city. In response, the Paris Council has implemented a 60 percent tax on second homes, defined as one furnished and lived in for less than 120 days a year and unoccupied homes, defined as one unfurnished and off the rental market for more than two years.[37] Paris Council has also made an ambitious commitment to increasing the number of affordable housing units it will provide to its residents, both by building new dwellings and converting existing ones into affordable units. The city plans to increase its public housing stock to 25 percent of all units by 2025 and 30 percent of all units by 2030. This means that every year, the city will finance the construction and conversion of 7,500 new public housing units.

Additionally, Paris has instituted a "first right to refuse" clause, wherein it has the first bid on certain buildings that are put up for sale.[38]

These radical housing plans are not only targeting low-income residents. Public housing units are available to residents at different income levels—from low-income to more affluent households—in order to increase socioeconomic diversity within buildings and within neighborhoods (see Figure 5). Under this scheme, 60 percent of the Paris population is eligible to apply for public housing.

Similarly, in the past few years, Vancouver had become one of the world's least affordable housing markets due to high demand from foreign investors, primarily from China. Both Vancouver and Toronto have instituted a 15 percent tax on home purchases by non-Canadian nationals and residents, as well as by international firms.

In addition, in order to incentivize more affordable rental units, city officials in Vancouver have passed a new law requiring developers to ensure up to 25 percent of new project units be rented at affordable rates for those earning between $25,000 to $65,000 (USD).[40] The Mayor of Vancouver announced plans to build 72,000 new units over the next 10 years, about half of which would be targeted at low and medium income residents.[41]

Will these radical experiments have their intended impact, or will housing prices continue to rise despite these interventions? Only time, and new data, will tell.

FIGURE 5: INCOME CEILINGS FOR PUBLIC HOUSING UNITS IN PARIS[39]

INCOME CEILING FOR SOCIAL HOUSING UNITS IN PARIS AND ITS SURROUNDING AREAS

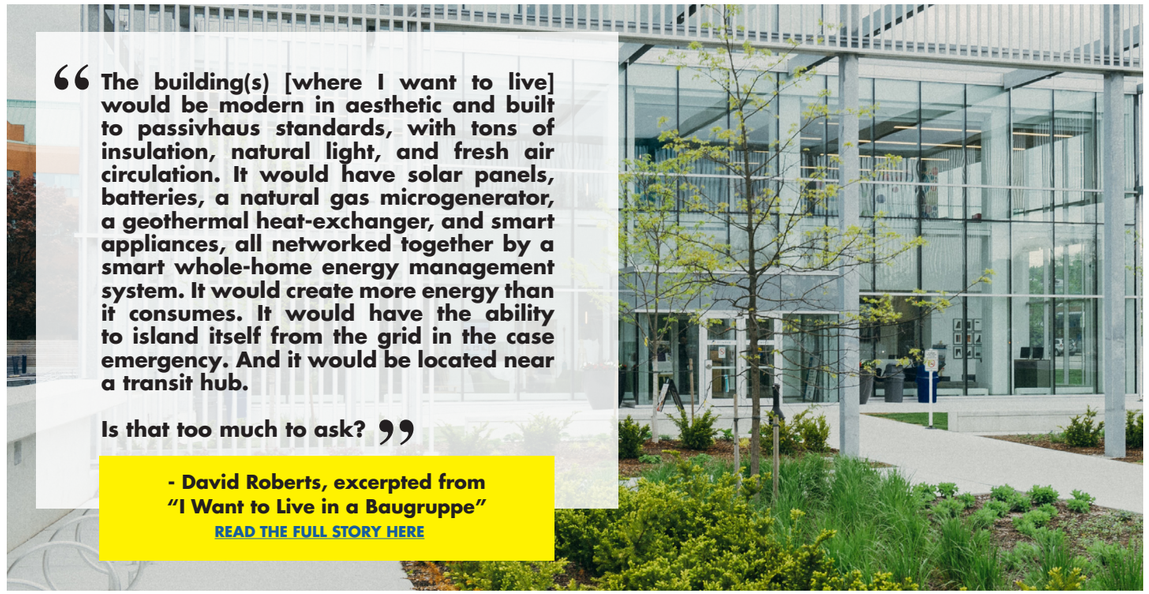
HOUSEHOLD MAKE UP	ENTRY-LEVEL DWELLING FOR VULNERABLE GROUPS	STANDARD SOCIAL HOUSING	HIGHER INCOMES SOCIAL DWELLINGS	UPPER LEVEL SOCIAL DWELLING (NOT COUNTED IN THE 25% SOCIAL HOUSING FIGURE OBLIGATION)
1 PERSON	€ 12,662	€ 23,019	€ 30,000	€ 41,434
2 PEOPLE	€ 20,643	€ 34,403	€ 44,724	€ 61,925
4 PEOPLE	€ 29,618	€ 53,845	€ 70,000	€ 89,165

3 CATEGORIES OF SOCIAL HOUSING DWELLING, WITH DIFFERENT LEVELS OF RENT, AND DIFFERENT LEVELS OF INCOME FOR THEIR TENANTS.

Source: http://www.afwc.nl/fileadmin/user_upload/Documenten/AFWC/Bestanden_2017/3_Paris_Bertrand_Bret.pdf

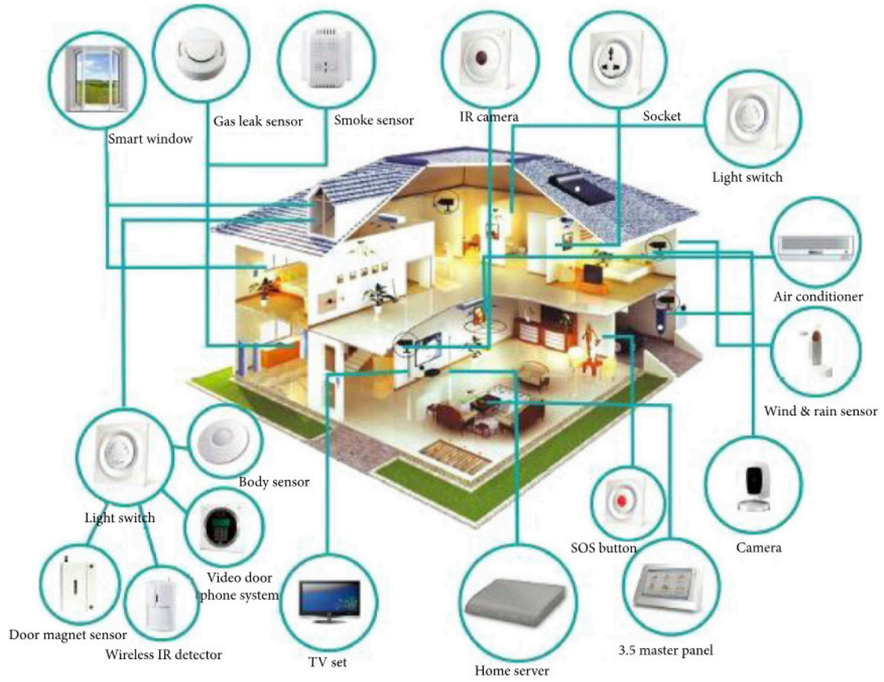
TECHNOLOGY

Emerging technologies with the potential to improve the function and experience of a home—ranging from smart and efficient energy technologies and the IOT to AI and digital environments—are slow to be integrated into existing and new housing at scale.[42]



[37] Feargus O'Sullivan, "Paris Is Tripling Its Tax on Second Homes," CityLab, January 26, 2017, https://www.citylab.com/equity/2017/01/paris-france-property-taxes-vacation-homes/514496/.
[38] "An Overview of Paris Habitat," Paris Habitat, accessed December 12, 2017, http://www.parishabitat.fr/Pages/Anglais-About-us.aspx.
[39] Bretrand Bret, "Social Housing in Paris," June 19, 2017, http://www.afwc.nl/fileadmin/user_upload/Documenten/AFWC/Bestanden_2017/3_Paris_Bertrand_Bret.pdf.
[40] Ben Nelms, "Vancouver Maps Out Plan to Help the City's Renters," The Globe and Mail, November 12, 2017, https://beta.theglobeandmail.com/news/british-columbia/vancouver-releases-rental-housing-plan-to-match-tenants-with-attainablerates/article35776108/?ref=http://www.theglobeandmail.com&.
[41] "City of Vancouver Puts Forward New Actions to Address the Housing Crisis for Lower Income and Homeless Residents," Vancouver Mayor's Office, July 26, 2017, http://www.mayorofvancouver.ca/news/city-vancouver-puts-forward-new-actions-address-housing-crisis-lower-income-and-homeless.
[42] Roberts, David, "I Want to Live in a Baugruppe," Grist, August 8, 2013, http://grist.org/cities/i-want-to-live-in-a-baugruppe/.

FIGURE 6: SMART HOMES



Source: https://www.hindawi.com/journals/js/2018/6464036/fig1/

Smart home devices, defined as any stand-alone object found in the home that is connected to the Internet, can be either monitored or controlled from a remote location, and have a non-computing primary function. These devices have the potential to not only improve the functions of a home but also life within it for residents. [43]

By 2020 there will be more than 20 billion connected items in homes around the world comprising a market worth $43 billion.[44] China, North America, and Western Europe are driving the growth of smart home devices and, together, represent two-thirds of installed devices in 2017.[45]

However, despite this estimated growth, these technologies have not been adopted at scale in a manner that is transformational for optimizing energy use, supporting the elderly, and bringing more convenience to the home. Consumers are increasingly aware of the benefits of adopting smart home technology, according to a study conducted by research firm Imre on behalf of U.S. national homebuilder, KB Home, and lock manufacturer, Kwikset. More than 60 percent of survey respondents agreed that smart home products could make a home more efficient and save energy and 46 percent of respondents agreed that smart home products make life more convenient.[46] Unfortunately, as demand for integrated smart home products rises, builders are faced with a new challenge: how to accommodate the emerging demand and simultaneously build a home that is compatible with the smart home technology of the future. With no clear market leader or integrated solution to provide direction, builders often neglect to incorporate these technologies.[47]

The following system failures are key contributors to this problem:

- High prices, coupled with long device replacement cycles, keep new technologies from at-scale adoption. For example, mass-market consumers will likely wait until their current device is broken to replace it. They will then compare a non-connected and connected product to see if the benefits make up for the price differential.[48]
- There is a lack of consumer awareness about the concept of the smart home as a whole.[49] While any individual device may improve functionality and connectivity of a home, the true transformation comes from the seamless integration of many devices. Few places exist where such integration can be demonstrated and even fewer where potential consumers can experience their benefits.[50]
- Currently, many different manufacturers, networks, standards, and devices are used to connect the smart home. This fragmentation creates interoperability challenges and makes it confusing for the consumer to set up and control multiple devices.
- Security and privacy concerns often keep people from adopting these technologies, many of which are devices with cameras and network access at risk of exposing family members to hacking and fraud. In addition, because of their limited computing capacity, most devices are not designed with serious protection capability and are indeed susceptible to attack.[51]

SNAPSHOT FROM THE CURRENT STATE: THE PROMISE OF A SLUM

KEY USER LENS:

- **Young and Aspirational**
- **Multifamily/Multigenerationl**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• Smart home technology becomes standard
MARKETS	• Incentives for mass adoption of Smart home technologies
POLICY	• Segmented affordable public housing available for all income levels • High taxes that discourage empty housing units • Taxes on second homes

[43] John Greenough, "The U.S. Smart Home Market has Been Struggling—Here's How and Why the Market Will Take Off," Business Insider, October 18, 2016, http://www.businessinsider.com/the-us-smart-home-market-report-adoption-forecasts-top-products-and-the-cost-and-fragmentation-problems-that-could-hinder-growth-2015-9.
[44] Rob van der Meulen, "Gartner Says 8.4 Billion Connected "Things" Will Be in Use in 2017, Up 31 Percent From 2016," Gartner. Inc., February 7, 2017, http://www.gartner.com/newsroom/id/3598917.; "Increasing Consumer Adoption of Smart Home Technology," IoT Innovation, accessed December 12, 2017. http://internet-of-things-innovation.com/insights/the-blog/increasing-consumer-adoption-smart-home-technology/#.WcQcTnTyuCR
[45] Van der Meulen, "Gartner."
[46] "Kwikset Consumer Smart Home Survey Results," Kwikset, September, 2015. https://www.cepro.com/images/pdfs/Kwikset_and_KB_Home_KWIKSET_CONSUMER_SMART_HOME_SURVEY_RESULTS_Fact_Sheet_March_2016_FINAL.pdf.
[47] Jimi Gonzalez, "Why Builders Need to Embrace the Home Technology Trend," Professional Builder, April 28, 2016, https://www.probuilder.com/blog/why-builders-need-embrace-home-technology-trend.
[48] Greenough, "The U.S. Smart Home."
[49] "Smart Home: Making the Smart Home a Reality," GFC, 2015, https://www.gfk.com/fileadmin/user_upload/dyna_content/Global/documents/Reports/GfK-smart-home-teaserdeck-global.pdf.
[50] "Insights on Consumer Attitudes to the Smart Home," GFC, 2016, http://www.gfk.com/fileadmin/user_upload/dyna_content/CH/images/Insights_2016/Smart_Home_Whitepaper.pdf.
[51] Javier E. David, "Alarm Grows as Smart Home Technology and Hacking Risks Proliferate," CNBC, November 5, 2016, https://www.cnbc.com/2016/11/04/alarm-grows-as-smart-home-technology-and-hacking-risks-proliferate.html.

Today, more than 1.1 billion people do not have access to electricity. Almost all live in three geographic regions: sub-Saharan Africa, South Asia, and Southeast Asia.[52] Lack of electricity access is highest in sub-Saharan Africa.[53] The region represents 13 percent of the global population, but 48 percent of the global population without electricity access.[54]

Moreover, sub-Saharan Africa is the only region in the world where the number of people living without access to electricity is increasing, as rapid population growth is outpacing efforts to provide electricity access. Since 2000, the total number of people without electricity access in the region has risen by approximately 100 million people.[55] Additionally, nearly 80 percent of people lacking electricity access in sub-Saharan Africa live in rural areas, where the cost of extending traditional electricity infrastructure is considered too high.[56]

These are villages that go dark when the sun sets. At night, many light homes with small kerosene lamps. These lamps only provide a small amount of light, similar to that of a candle, and are dangerous. Kerosene lamps give off polluting black fumes that are harmful to inhale.[57] Kerosene lamps often lead to accidents as they can easily set fire to an entire home, or even an entire village, if they are knocked over.

What if, instead of kerosene, these homes could utilize LED lights? What if the electricity to power these bulbs cost less than kerosene? What if these brighter, safer spaces enabled children to study in the evening or allowed women to take in work such as weaving or sewing?

A group known as the "solar mamas" in Zanzibar, a region of Tanzania in East Africa, are turning these "what ifs" into reality.

Beginning about a decade ago, Barefoot College, a nonprofit based in rural India, began training middle-aged women from rural villages, often illiterate or semi-literate, to become solar engineers. These self-proclaimed "solar mamas" are paid to install and maintain solar systems that now serve 40,000 rural households (500,000 people) in the developing world.

Source: https://www.flickr.com/photos/88922124@N07/31224380082/in/album-72157674532230575/

Source: https://www.pri.org/stories/2015-06-05/zanzibars-solar-mamas-flip-switch-rural-homes-gender-roles

Barefoot provides solar equipment and panels to villages, and each household that uses the panels for electricity pays into a village fund that covers the women's salaries and maintenance of the equipment. Since 2006, Barefoot has trained more than 700 women in 1,265 villages across 70 countries. The college now has five regional training centers across Africa, Latin America, and the Pacific Islands, in addition to its main campus in the Tilonia village of Rajasthan, India.[58, 59]

Why has this program been successful where others have failed? Many electrification programs rely on tools and technologies that are complicated to install and maintain, creating communities dependent on skills and services that may not be available within the village or even within the region. Perhaps more importantly, programs often seek to impose solutions on villages, rather than work with village residents themselves—and within their cultures and lifestyles.

Barefoot takes the additional step of focusing their recruitment on women. They have found that, once trained, men often sought work in cities and left their families behind. Women, especially middle-aged grandmothers, tended to be more embedded in their community and stay and support their villages.[60]

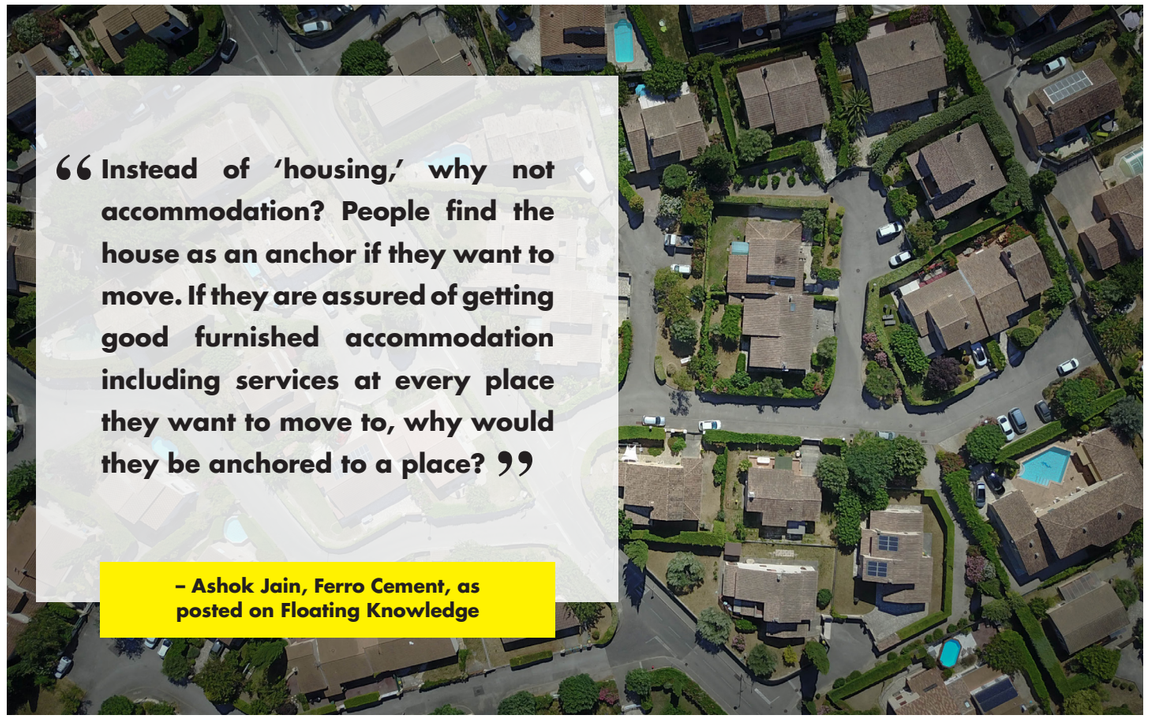
The center of life for women in rural villages, the common denominator, is the home. By transforming women into Solar Mamas, Barefoot has found a way to transform the home into not just electric power but empowerment.

[52] "Energy Access," International Energy Agency, accessed December 15, 2017, https://www.iea.org/energyaccess/.
[53] According to United Nations definitions, s. ub-Saharan Africa includes all countries on the African continent except Western Sahara, Morocco, Algeria, Tunisia, Libya, and Egypt.
[54] Antonio Castellano, Adam Kendall, Mikhail Nikomarov, and Tarryn Swemmer, "Brighter Africa," McKinsey and Company, February 2015, 2. .
[55] "Africa Energy Outlook," International Energy Agency, 2014, 30.
[56] International Energy Agency, "Africa."
[57] Sam Eaton, "Zanzibar's 'Solar Mamas' Flip the Switch on Rural Homes, Gender Roles," PRI, June 5, 2015, https://www.pri.org/stories/2015-06-05/zanzibars-solar-mamas-flip-switch-rural-homes-gender-roles.
[58] Yasmin Waljee, "Let There Be Light: The Business Partnership Training Women to Illuminate the Developing World," City A.M., September 6, 2017, http://www.cityam.com/271442/let-there-light-business-partnership-training-women.
[59] "Women Barefoot Solar Engineers," Barefoot College, accessed December 13, 2017, http://barefootcollege-zanzibar.org/solar/.
[60] Waljee, "Let There Be Light."

ADAPTABILITY

Housing cannot be easily modified or adapted to changing demographics, lifestyles, and other needs. We adapt to the housing stock, the housing stock doesn't adapt to us.

Housing does not generally adapt to the changing needs of its owners or occupants. Modification, expansion, and renovation are expensive and time consuming. Individual buildings, land boundaries and usage, and community or urban structures cannot be easily modified or adapted to changing needs, community demographics, or lifestyles.



In many countries, housing structures are designed to last multiple generations, slowing the demand for and introduction of new construction techniques, materials, and technologies. Many elements of modern housing can last in excess of 100 years.[61] Moreover, a recent study by McKinsey and Company concluded that in many places, residential housing is essentially built the same way it was 50 years ago.[62]

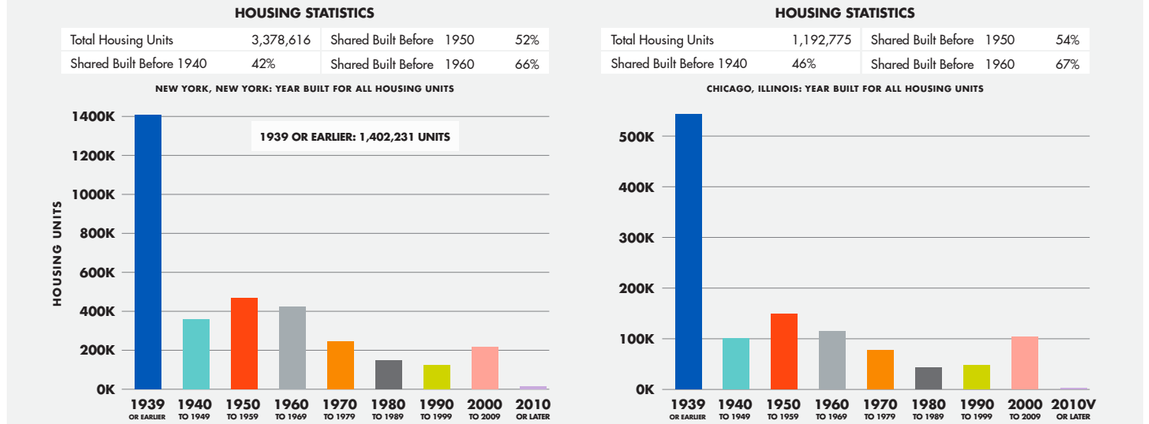
While older housing stock can add charm and character to communities, aging housing stock slows the adoption of new technologies, construction techniques, and building codes.[63] Older buildings are more expensive to retrofit and require more maintenance. In the U.S., the average age of housing stock was 37 years as of 2013—up from 27 years a decade earlier. Forty percent of U.S. housing was built before 1969.[64] Almost 25 percent of Europe's housing stock was built before 1945.[65]

In contrast, Japan offers opportunities for more dynamism in its housing stock due to regulatory structures that assume more limited lifespans. Japanese housing is generally torn down and rebuilt within 20 years for wooden buildings and 30 years for concrete buildings.[67] This allows Japan to pursue enhancement of the quality of housing as an important part of national housing policy in the 21st century.[68] Legal and regulatory structures also make housing less readily adaptable to changing needs and opportunities. For example, zoning laws and building codes that require minimum square footage for new construction homes can defeat adoption of tiny homes, residential structures that are under 500 square feet in size.[69] Amending or changing zoning codes can take decades and, in some countries, are subject to judicial review. Furthermore, zoning and land use restrictions can be manipulated to drive up housing prices and ultimately making existing housing stock less adaptable to changing needs.[70]

The following system failures are key contributors to this problem:

- Architecture is largely bespoke and difficult to change or scale to the evolving needs of owners and occupants.
- Housing remains a prestige product,

FIGURE 7: AGE OF HOUSING STOCK IN NEW YORK AND CHICAGO[66]



[61] "Average Life Span of Homes, Appliances, and Mechanicals," Attention to Detail, accessed December 15, 2017. http://www.atdhomeinspection.com/advice/average-product-life/.; "InterNACHI's Standard Estimated Life Expectancy Chart for Homes," InterNACHI, accessed December 15, 2017, https://www.nachi.org/life-expectancy.htm.
[62] Garemo, "Tackling."
[63] Mike Maciag, "The Implications of Older Housing Stock for Cities," Governing, September, 2014, http://www.governing.com/topics/urban/gov-cities-old-housing-stock.html.
[64] Na Zhao, "The Aging Housing Stock," National Association of Home Builders, August 11, 2015, http://eyeonhousing.org/2015/08/the-aging-housing-stock-2/.
[65] "Urban Europe—Statistics on Cities, Towns, and Suburbs—Housing in Cities," Eurostat, April 2016, http://ec.europa.eu/eurostat/statistics-explained/index.php/Urban_Europe_—_statistics_on_cities,_towns_and_suburbs_—_housing_in_cities.
[66] Maciag, "The Implications."
[67] Greg Rosalsky, "Why Are Japanese Homes Disposable? A New Freakonomics Radio Podcast," Freakonomics, February 27, 2014, http://freakonomics.com/podcast/why-are-japanese-homes-disposable-a-new-freakonomics-radio-podcast-3/
[68] Masahiro Kobayashi, "The Housing Market and Housing Policies in Japan," Asian Development Bank Institute Working Paper, no. 558, (2016): 3, https://www.adb.org/sites/default/files/publication/181404/adbi-wp558.pdf.
[69] "About," Tiny House Town, accessed December 13, 2017, http://www.tinyhousetown.net/p/about-blog.html.; Emily Nonko, "Tiny House Zoning Regulations: What You Need to Know," Curbed, September 22, 2016, https://www.curbed.com/2016/9/22/13002832/tiny-house-zoning-laws-regulations.
[70] Edward L. Glaeser and Joseph Gyourko, "The Impact of Zoning on Affordable Housing," Harvard University, discussion paper no. 1948, March 2002, https://web.archive.org/web/20070926031356/http://post.economics.harvard.edu/hier/2002papers/HIER1948.pdf.; John Cochrane, "Zoning and Inequality," The Grumpy Economist, December 3, 2015, http://johnhcochrane.blogspot.com/2015/12/zoning-and-inequality.html.

signifying wealth and position in society. This, in turn, drives individuals and communities to defend and pursue housing, policies, and regulatory systems that enhance the financial value of housing. These policies make housing less accessible and adaptable for the majority of citizens.[71]

- Permitting, zoning, and other regulatory schemes are complex and restrictive by design.[72] "Zoning regulations and other local barriers to housing development allow a small number of individuals to capture the economic benefits of living in a community, thus limiting diversity and mobility," said Jason Furman, former chair of the President's Council of Economic Advisors.[73]
- Laws for how communities divide and utilize land are difficult and time consuming to change.[74]

SNAPSHOT FROM THE CURRENT STATE: THE PROMISE OF A SLUM

KEY USER LENS:

- **Young and Aspirational**
- **The New Middle**
- **Affluent and Savvy**
- **Multifamily/Multigenerational**
- **Elderly and Infirm**
- **Refugees and Slum Dwellers**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY

- Fabrics and building materials capable of harnessing solar power for electricity
- Flooring that generates electricity from kinetic energy (walking, playing, moving, etc.)
- Closed loop homes (waste, electricity, water)
- Integrated smart home solutions that are not one-off and are capable of operating together seamlessly (today there is no whole home solution, and devices can not "talk" and operate with one another)
- Housing incubator spaces that are capable of displaying new building materials and housing technologies that work, so that both the public and governments can observe and make decisions to integrate these technologies (policy changes, commercial adoption, etc.)

MARKETS

- Novel ways of integrating community input into the residential building process
- New ownership models that allow residence to pay for living with their skills, services, and abilities

POLICY

- New ownership models like "work to live"

In Germany, co-housing schemes (often called "baugruppen" or building groups) are becoming an increasingly popular form of living arrangement. While these projects vary in size and type, they are typically forms of communal living where individuals or families live in their own space while sharing, managing, and maintaining communal spaces and amenities together. Public or private developers or groups of individuals can develop these building groups.

Co-housing projects are typically cheaper than private market units and range from rental to owner-occupied communities. For example, the cost of an apartment in Berlin is 25-30 percent less expensive for a baugruppen than it is for regular housing. That's primarily because owners share down payment costs and the profit margin for a developer is eliminated.[75]

The first co-housing projects were built in Germany in the 1970s, but since the early 2000s, there has been a steady increase in demand for these types of homes, and many municipalities across Germany are incentivizing baugruppen developments.[76] The city of Berlin offers land to baugruppen based on the quality of their residential concept and holds the land for the group until they can raise the necessary funds and partners to develop the project. Co-housing projects are also considered a successful way to create social cohesion and to provide alternative living arrangements that fulfill a wide range of needs. These types of developments also create jobs and affordable housing in city boundaries, and are often built on odd-shaped or empty lots that would otherwise be considered unattractive to developers.

These housing schemes appeal to different kinds of people with varied needs and interests. Aside from cheaper rent or building costs, people are attracted to co-housing for the experience of living in a community. For the elderly, co-housing can be a way to live among their peers, or to live in multigenerational communities. Some families want to raise their children with others, and enjoy easy access to onsite childcare, whether that is through sharing the responsibility of childcare with neighbors or having a communal childcare facility onsite. For young people, co-housing can be a way to access amenities that would otherwise be unaffordable to them, such as gardens and gathering spaces.

In Berlin, baugruppen have been emerging as a solution to the affordable housing shortage and frustration from residents about escalating costs for both renting and ownership. In Berlin, groups of residents pool funds for the construction and purchase of the plot and design a co-housing scheme alongside architects and designers of their choosing. Building without developers can make projects significantly cheaper, and can lead to more ambitious, creative, or sustainable designs.

Today, one in 10 of all new homes built in Berlin are now baugruppen. Many people in Germany are ready to embrace baugruppen life.

[71] Cochrane, "Zoning."
[72] "The Governance of Land Use," The Organisation for Economic Co-operation and Development, 2017, 21, https://www.oecd.org/cfe/regional-policy/governance-of-land-use-policy-highlights.pdf.
[73] Cochrane, "Zoning."
[74] Will Van Vactor, "Zoning Ordinances and Regulations," Lawyers, accessed December 13, 2017. https://zoning-planning-land-use.lawyers.com/zoning-ordinances-and-regulations.html.
[75] Winnie yuen-pik Chan, "The Phenomenon of Building Group (Baugruppe) in Berlin: What Changes When a Community Starts Building?" (Master Thesis, Anhalt University of Applied Sciences, 2010), https://issuu.com/winnie/docs/thesis_book.
[76] Christian Tröster, "Baugruppen-Boom in den Metropolen," Berliner Morgenpost, December 11, 2013, https://www.morgenpost.de/printarchiv/immobilien/article122795147/Baugruppen-Boom-in-den-Metropolen.html.
[77] Jessica Bridger, "Don't Call It a Commune: Inside Berlin's Radical Co-housing Project," Metropolis, June 10, 2015, http://www.metropolismag.com/architecture/residential-architecture/dont-call-it-a-commune-inside-berlin-radical-cohousing-project/.

SNAPSHOT FROM THE CURRENT STATE: WHEN "INCREMENTAL" IS TRANSFORMATIONAL

The U.N. predicts that sub-Saharan Africa's urban inhabitants will more than triple from 995 million in 2016 to between 1.5-2 billion by 2050, accounting for 56 percent of the region's population. Lagos, the jam-packed commercial capital of Nigeria, has a population estimated anywhere between 12 million and 21 million.[80] An estimated 12 million people live in Kinshasa, Democratic Republic of Congo.[81] By 2030 Dar es Salaam, Tanzania; Johannesburg, South Africa; and Luanda, Angola will have joined the ranks of Lagos and Kinshasa with more than 10 million people living in each.[82] People are moving to these emerging megacities in droves—and the current housing stock is not ready for them.[83]

Slums in sub-Saharan African countries are doubling in size every 15 years.[84] As more and more people migrate to cities in search of work and better economic opportunities, access to safe, adequate, and affordable housing is a growing crisis.

Some traditional efforts to address the issue are underway. In May of 2015, the International Finance Corporation (IFC) and CITIC Construction, a Chinese multinational construction and engineering company, launched a $300 million investment platform to grow affordable housing stock in exploding megacities across multiple African countries.[85] However, Africa's housing markets have few local developers with the technical and financial expertise to successfully execute large-scale projects, and even when they can be executed, the resulting housing units are often too expensive for potential residence who lack access to any form of credit.

Is there better way to address this impending crisis?

Some architects and developers are beginning to explore a more incremental approach to housing development that mimics evolution of informal housing itself. These incremental housing approaches, also called phased-development housing or owner-driven housing, are a step-by-step process that gives homeowners choices and allows for accumulative upgrades as resources allow.[86] The process typically begins with a starter core shelter. The starter core may be a multi-purpose room with basic kitchen and bath facilities or just a bare lot with utility connection potential. A wide range of starter options are now available to fit specific developing world contexts, from single story units to multistory expandable apartments for locations with higher population densities. Dr. Reinhard Goethert, a professor at the Massachusetts Institute of Technology (MIT) and an expert on incremental housing, has stressed that standards need to be reoriented to reflect and embrace a pay-as-you go process and that infrastructure may also need to be developed incrementally as well, to parallel growth and demands at both the neighborhood and individual home level.

A version of this incremental approach to development was adopted in the 1970s by housing agencies worldwide and was previously known as "site and service." However, many projects were deemed failures because they were evaluated not as a new kind of process, but rather by the criteria of a traditional affordable housing project.[87] As a result, site and service projects fell out of favor by the mid-1980s. However, recently there has been a renewed interest in understanding how

[77] Jessica Bridger, "Don't Call It a Commune: Inside Berlin's Radical Co-housing Project," Metropolis, June 10, 2015, http://www.metropolismag.com/architecture/residential-architecture/dont-call-it-a-commune-inside-berlin-radical-cohousing-project/.
[78] "Berlin—'Building Groups,'" The Self Build Portal, accessed December 13, 2017, http://www.selfbuildportal.org.uk/berlin-building-groups.
[79] "Africa and Asia to Lead Urban Population Growth in Next 40 Years," United Nations News Centre, April 5, 2012, http://www.un.org/apps/news/story.asp?NewsID=41722#.WjQRnLQ-dPM.
[80] A combination of rapid migration and lack of resources for estimating populations has led to an inability to conduct an accurate population count. John Campbell, "This Is Africa's New Biggest City: Lagos, Nigeria, Population 21 Million," The Atlantic, July 10, 2012, https://www.theatlantic.com/international/archive/2012/07/this-is-africas-new-biggest-city-lagos-nigeria-population-21-million/259611/.
[81] "Demographia World Urban Area," Demographia, April 2017, http://www.demographia.com/db-worldua.pdf.
[82] "For Most Urban Africans, Owning Anything Other Than a Slum Home Is out of Reach," The Economist, December 15, 2015, https://www.economist.com/news/middle-east-and-africa/21684033-unaffordable-houses-make-sub-saharan-africa-worlds-smallest-mortgage.
[83] The Economist, "For Most Urban Africans."
[84] The Economist, "For Most Urban Africans."
[85] International Finance Corporation, "Affordable."
[86] Reinhard Goethert, "Incremental Housing," Monday Developments Massachusetts Institute of Technology, September 2010, http://web.mit.edu/incrementalhousing/articlesPhotographs/pdfs/PagesMondayMag.pdf.
[87] Goethert, "Incremental."

some of these approaches have been successful and could work today.[88]

Chilean architect Alejandro Aravena, the 2016 Pritzker Prize winner and Executive Director of housing and public space infrastructure firm Elemental, is an outspoken champion of incremental housing. Arevana is best known for his participatory approach that engages local communities in the early stages of the design process and encourages governments to fund construction of "half a good house," with residents completing the other portion as resources allow.[89]

Arevena and his team at Elemental have shared drawings for four of their low-cost incremental housing projects online, allowing governments agencies and developers to download the plans for free. The open-sourced designs have been tested and implemented in a number of real-life contexts, taking into consideration budget and policy constraints, and have proved to be beneficial to communities by allowing for improvements on a pay-as-you-go process.[90] Arevena and his team ultimately hope to eliminate the hurdle of expensive design plans that halt markets and governments from moving toward innovative solutions for tackling the rapid urbanization in the global south.[91]

Incremental housing has the potential to be an affordable way to rapidly resettle many families at a minimum housing and services level by linking the energy of families with the large-scale city planning.[92] But it is more than housing. It also builds community and develops social networks that can support services and small-scale commercial opportunities.[93] This incremental solution just might be transformational.

RESILIENCE

Although there is a growing recognition of the need for greater resilience and adaptation in the face of climate change, there is continued underinvestment relative to the scope and pace of the challenge.[94]

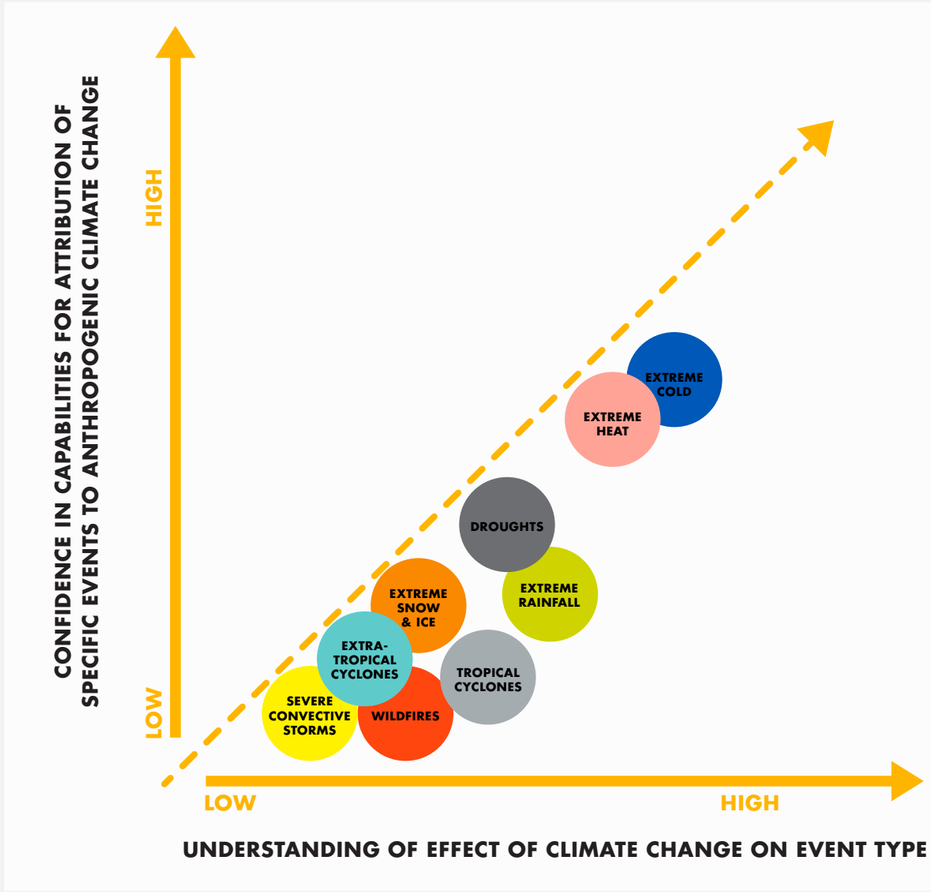
Recent years have seen record-breaking weather extremes, with the three warmest years on record for the globe in 2015, 2016, and 2017. These trends are expected to continue over the next several decades. Costs from extreme weather events, such as hurricanes and wildfires, are often in the hundreds of billions of dollars. Damage from Hurricane Katrina in 2005 totaled more than $100 billion, with some estimates placing the total

economic damages at $250 billion. Damages from the most recent hurricanes, Harvey and Irma in September 2017, are estimated to cost approximately $290 billion.

Moreover, the science related to attributing extreme weather events to climate change has progressed significantly in recent years (see Figure 8). There is now higher confidence in the causation between climate change and extreme weather, including extreme heat and cold as well as drought. The causation of other types of events, such as wildfires, is currently less understood, but likely to improve in the coming years.

[88] "Incremental Housing," Massachusetts Institute of Technology, accessed December 13, 2017, http://web.mit.edu/incrementalhousing/.
[89] Jenna McKnight, "Alejandro Aravena Makes Housing Designs Available to the Public for Free," Dezeen, April 6, 2016. https://www.dezeen.com/2016/04/06/alejandro-aravena-elemental-social-housing-designs-architecture-open-source-pritzker/.
[91] McKnight, "Alejandro."
[90] McKnight, "Alejandro."
[92] Goethert, "Incremental."
[93] Goethert, "Incremental."
[94] Josie Ortegon, "Extreme Weather Task Force Urging Public to Take Precaution as Temps Heat up," KVIA, June 22, 2017, http://www.kvia.com/news/el-paso/extreme-weather-task-force-urging-public-to-take-precaution-as-temps-heat-up/557539554
[95] David Fahey, Kathleen Hibbard, and Donald Wuebbles, "U.S. Global Change Research Program Climate Science Special Report," June 28, 2017, https://assets.documentcloud.org/documents/3920195/Final-Draft-of-the-Climate-Science-Special-Report.pdf.
[96] Kimberly Amadeo, "Hurricane Katrina Facts: Damage and Costs," The Balance, September 8, 2017, https://www.thebalance.com/hurricane-katrina-facts-damage-and-economic-effects-3306023.
[97] Karma Allen and Maia Davis, "Hurricanes Harvey and Irma May Have Caused up to $200 Billion in Damage, Comparable to Katrina," AbcNews, September 11, 2017, http://abcnews.go.com/US/hurricanes-harvey-irma-cost-us-economy-290-billion/story?id=49761970.

FIGURE 8: CONFIDENCE IN ATTRIBUTING EXTREME WEATHER TO HUMAN-INDUCED CLIMATE CHANGE, 2016 [98]



Confidence in attribution is higher for events such as more frequent heat waves and less frequesnt cold snaps, which are linked to human-caused increases in global temperatures through an understood and robustly simulated physical mechanism. There is less confidence in the attribution of other types of events, such as tropical cyclones that are related to climate changes in more complex and less understood ways.

More extreme weather, in particular extreme heat and cold, will have a direct and significant impact on homes. Although there is increasing public discussion about resiliency in the face of climate change and extreme weather (see "The Rise of the Chief Resiliency Officer Information" box) there is not action at the scale and pace necessary to address the problem. According to the U.N., developing countries will need more than $140 billion annually to adapt to climate change, but adaptation finance in 2013 was only $25 billion, leaving at least a $115 billion gap.[99]

The following system failures are key contributors to this problem:

- Urban planning policies, including zoning, building codes, and standards policies are focused on reducing risk of liability and ensuring safety, but in many cases do not contemplate or allow for innovative materials and methods that would address resiliency and sustainability.

- Government-set standards and building codes are typically based on historical climate information.[100] That information is increasingly misaligned with the realities of severe weather.

- There is a lack of private sector financial incentives to address resilience-building measures. In particular, the business case for such projects is often unclear or weak because they include avoided losses or impacts that do not occur.[101]

- Regulator culture is inherently conservative and not designed to be nimble or easily pivot from traditional approaches that may be outdated. Regulatory processes often hinder the adoption of more sustainable materials and practices that could slow or reverse global resource depletion. For example, glass remains an attractive building material because it's sleek, modern, creates an open feel, and is not too expensive. However, glass creates enormous inefficiencies with respect to heating and cooling; one study compared the efficiency of glass buildings to medieval-era houses.[102]

- Cooling technologies in particular will grow in demand with hotter temperatures and increasing wealth among populations globally. A study by the Lawrence Berkeley National Laboratory, a Department of Energy lab managed by the University of California, found that air conditioner ownership increased 2.7 percent for every $1,000 increase in annual household income.[103] However, air conditioning remains energy intensive and is itself a significant contributor to greenhouse gas emissions that drive climate change.[104]

THE RISE OF THE CHIEF RESILIENCY OFFICER

In 2014, the Rockefeller Foundation offered grant funding for cities to create a new job focused on ensuring resilience. More than 300 cities from 94 countries applied for 35 awards. The result was a new cadre of chief resiliency officers (CROs) whose focus includes reducing greenhouse gas emissions and adapting to climate change. These lofty goals have lead to work that creates better-educated communities, addresses chronic poverty and inequality, identifies inadequate housing conditions, and diversifies the economic base to prepare for an uncertain future.

"Many chief resilience officers have urban planning, transportation, or emergency management backgrounds. Some come to the role with years of municipal management experience behind them, and a nuanced understanding of how crucial it is to have someone who can work across departments," Erika Bolstad wrote in ClimateWire. In fact, one critical characteristic for the position to have an impact is the CRO must not be viewed as merely a figurehead. The positions also enable cities to take a holistic, and human-centered, view of their future. As Jeff Hebert, a chief resiliency officer in New Orleans said, "We have to focus not just on infrastructure and natural systems and mitigation of climate, but also address the people side of the coin."

READ MORE HERE

[98] "Attribution of Extreme Weather Events in the Context of Climate Change," The National Academy of Sciences, 2016, https://www.nap.edu/resource/21852/Attribution-Extreme-Weather-Brief-Final.pdf.
[99] "Climate Resilience," World Resources Institute, accessed December 13, 2017, http://www.wri.org/our-work/topics/climate-resilience
[100] "Energy, Climate Change, and Environment," International Energy Agency, November 4, 2016, http://www.iea.org/publications/freepublications/publication/ECCE2016.pdf.
[101] International Energy Agency, "Energy."
[102] Courtney Humphries, "Boston Wants to Fight Climate Change. So Why Is Every New Building Made of Glass?" The Boston Globe, July 14, 2017, https://www.bostonglobe.com/ideas/2017/07/14/boston-wants-fight-climate-change-why-every-new-building-made-glass/bPHKGwPxuuwsxHHTdlwmNJ/story.html.
[103] Brady Dennis and Chris Mooney, "The World Is About to Install 700 Million Air Conditioners. Here's What That Means for the Climate," The Washington Post, May 31, 2016, https://www.washingtonpost.com/news/energy-environment/wp/2016/05/31/the-world-is-about-to-install-700-million-air-conditioners-heres-what-that-means-for-the-climate/?utm_term=.25b7efed6a62.
[104] Bolstad, Erika, "Coastal Cities Look to Resilience Chiefs to Combat Climate Change," The Scientific American, May 23, 2016, https://www.scientificamerican.com/article/coastal-cities-look-to-resilience-chiefs-to-combat-climate-change/.

SNAPSHOT FROM THE CURRENT STATE: A LITTLE MORE LIKE HOME

KEY USER LENS:

- **Refugees and Slum Dwellers**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY
- Partially built housing units manufactured at scale. Allow urban poor to then build on to unit as resources permit (see Snapshot).
- Utilities that can be completely off-grid.
- Refugee housing that can truly be created and employed at scale using technologies like 3D printing to develop homes on site in less than 24 hours
- Rolls of concrete sheets that can be unrolled over a light metal frame and then sprayed with water to harden and develop a structure. (Picture a blanket fort that can then become rigid and stand on its own without support).
- Pocketable devices capable of heating or cooling spaces to comfortable conditions within minutes.

MARKETS
- Partially built housing units manufactured at scale. Allow urban poor to then build on to unit as resources permit.
- New markets that support extreme modularity for quick building.

POLICY
- Building codes that allow for experimentation; experimentation zones that can show proof of concept.

The world is facing its largest refugee crisis since World War II. Global displacement reached an all-time high of 65 million people in 2016, including more than 20 million refugees and 40 million displaced persons.[105] The U.S. invasion of Iraq, civil conflict in Colombia, the South Sudanese civil war, and conflict in Burma are all drivers of this increase. The largest driver by far, however, is the war in Syria, which has displaced approximately 12 million people between 2011 and 2017.[106]

What happens to individuals and families when they no have longer a place to call home? Amidst war, civil conflict, famine, and natural disaster, the notion of home has changed dramatically for millions of people around the world. For many, home has become little more than a branded tent and the hearts that inhabit it.

But there is a movement to changes this.

With innovative design and cutting-edge technology, organizations around the world are working to bring dignity, safety, and privacy back to the home for refugees. "Refugee architecture" is now a focus area for many architects and designers, resulting in some truly innovative and beautiful designs for temporary homes and emergency shelters.

In recent years, three innovative designs have come the closest to providing quality, affordable, scalable housing for displaced persons while meeting some of their essential needs. Two of these shelters are designed for manufacturing and scalability, and forgo the "wow" factor for functionality and ease of production and setup.

IKEA BETTER SHELTER:
The Better Shelter is a single-room emergency shelter designed to radically improve upon the standard U.N. tent. The shelter consists of a steel foundation, a roof with ventilation, a solar panel (to provide light and enable mobile device charging), and walls with windows and one door. The shelter is designed to house five people. It is shipped flat in two boxes (80 kg each) and takes four people four to eight hours to construct by hand. It sells for $1,150 (USD) per unit.[107] In 2015, IKEA sent 500 of its Better Shelters to Greece, and the Swiss government is using them for refugees (inside a larger, insulated structure, to mitigate the cold climate in Switzerland). IKEA also delivered its first large shipment of 10,000 units to the U.N. in 2015.[108]

EXO EMERGENCY SHELTER:
The Exo Emergency Shelter by Reaction, an Austin, Texas based housing company, is a single-unit shelter designed for emergency response. It contains two primary pieces—a floor and a shell (the walls and roof)—that are easily stacked for transport and storage when not in use. The shelter sleeps four and comes standard with locking doors, LED lights, power outlets, and climate control and ventilation. It was designed to be set up within 24 hours and last five to 10 years.[109] As with the Better Shelter, the Exo is designed as a standalone unit with materials sourced overseas. It costs approximately $5,000 (USD) per unit.[110]

HUMANIHUT SHELTER SYSTEM:
The Humanihut is a single-room shelter that sleeps up to six people and is designed to be used for emergencies as well as longer-term housing. Each Humanihut includes a raised hard floor; access to 110-volt power and fresh drinking water; integrated furniture including beds, a table, and benches; a sink; integrated cooking elements; and heating. The units are designed to be set up in rows, creating a shared power and water grid. One sanitation unit, called an Ablutionhut, contains toilet, shower, and laundry facilities and is intended to be deployed for every 16 Humanihut units. Each Humanihut unit can be erected in just five minutes by a small team with a forklift, and a row of 16 units and one Ablutionhut can be ready for use in just 90 minutes. The units can easily be deployed, taken down, and redeployed elsewhere in a short period of time.[111]

The three designs above, particularly the Humanihut Shelter System, offer a vast improvement over the standard United Nations High Commissioner for

[105] "Global Trends: Forced Displacement in 2016," United Nations High Commissioner for Refugees, 2016, http://www.unhcr.org/5943e8a34.pdf.
[106] "Syria Emergency," United Nations High Commissioner for Refugees, December 7, 2017, http://www.unhcr.org/en-us/syria-emergency.html.
[107] "A Better Shelter," Better Shelter, accessed December 14, 2017, www.bettershelter.org/product.
[108] Elizabeth Cullen Dunn, "Better Than a Tent, Worse Than a House," Slate, October 1, 2015, http://www.slate.com/articles/technology/future_tense/2015/10/ikea_gives_10_000_flat_pack_shelters_for_refugees.html.
[109] "Tech Specs," Reaction, accessed December 14, 2017 www.reactioninc.com/exo/tech-specs.
[110] Allison Leahy, "Reaction Housing System: A Rapid Response Flat-Pack Emergency Shelter," Inhabitat, September 1, 2011, www.inhabitat.com/reaction-housing-system-a-rapid-response-flat-pak-emergency-shelter.
[111] Julie M. Rodriguez, "All-In-One Humanihut Emergency Shelters Set up in Five Fast Minutes," Inhabitat, June 10, 2016, www.inhabitat.com/all-in-one-humanihut-emergency-shelters-can-be-set-up-in-five-fast-minutes.

Refugees (UNHCR) tent and shipping container homes used in some camps. While the Humanihut could provide the majority of essential needs of displaced persons in emergency situations, these facilities may be insufficient for long-term living, particularly with respect to environmental, community, and cultural relevance, and they are not designed for use outside of camp settings. Additionally, these solutions are one-size-fits-all models, and have not, with the exception of the IKEA Better Shelter, been implemented at scale.

While there are great strides being made to bring the dignity of home back to refugees and displaced populations, there is still plenty of room for innovation. Who will be the next innovator to make refugee housing feel "a little more like home"?

ENVIRONMENT

Building housing requires significant natural resources, which impacts ecosystems as the demand for resources increases. Construction waste and the impact of cities on natural habitats are also significant.

Demand for housing is increasing rapidly due to the necessary commitment to shelter people, increasing global populations, and more individuals moving into the middle class. This demand comes with a heavy cost for our natural resources. Specifically, materials such as wood, fiber, glass, concrete, and petrochemicals require significant extraction from the natural world. Between 50-75 percent of all diminishing natural resources are used by the building industry, with a particular impact on forest habitats.[112]

Timber production and mining—particularly for aggregate and other minerals used in building materials such as concrete and glass—are increasing rapidly, leading to a concomitant rise in deforestation and denuded landscapes. These demands are leading to degraded natural habitats that support biodiversity and ecosystem services.[113]

Forests provide significant ecosystem services to human communities, including fresh water, pollution control, and production of non-timber resources. Degradation of these habitats for building materials has the perverse effect of reducing ecosystem services that also support cities.

Construction waste is the largest driver of solid waste globally. About 40-50 percent of landfills are made up from unused or disposed building materials, including waste from demolished homes.[115] This is a clear opportunity for both significantly more efficient use of materials and the recycling of construction materials when rebuilding housing stocks.

As people move into cities, impact on the natural environment is increasing. Land consumption and encroachment of the urban footprint onto natural habitats results in habitat fragmentation, desertification, and habitat loss. Each of these trends serves to accelerate species extinction and the loss of ecosystem services.[116]

Increased urbanization also leads to larger localized impacts due to concentrated human dwellings. Pollution, solid waste, and the alteration of terrestrial and coastal habitats downstream of cities impact species and habitats. Often, these habitats are in vulnerable ecosystems, such as coastal zones and major river networks, which result in significant environmental damage.[117]

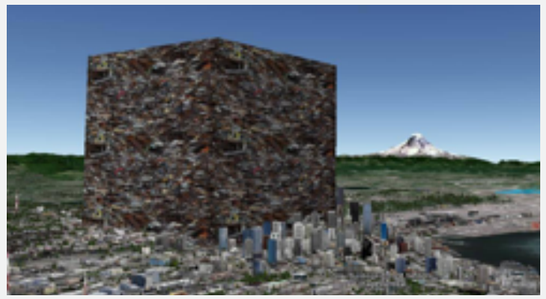
As human populations increase, so too does the demand for food and other resources. Demands for agricultural production and available water can result in fragile ecosystems and urban-hinterland systems that are vulnerable to disruption from natural disasters.

Land stock around the world, especially in cities, is diminishing; resulting in sharp rises in cost and affordable access. Land in many areas is subject to corruption and misuse. Considering that available land is the basis for all housing needs, recognizing the need to protect such land and its perpetual utility by local authorities is essential. Some emerging policies are beginning to codify the value of land in such a way. In India, the federal government recognized the Ganges River as its own entity, like a person, and gave it rights.[118] Violations of the river can now be considered similar to violating human rights, thus enabling greater protection and recognition of its valuable resources.

In order to lead to a preferred future, housing must explicitly consider the resources that are being used to generate construction materials. A focus on the creation of new materials that are adaptable, affordable, non-toxic and biomimetic and can replace current wood, stone, and other natural materials would begin to address this issue.

The communities and cities in which housing is built should explicitly consider the natural environment. Typically, housing and urban developments are commissioned in spite of the natural environment, leading to habitat fragmentation and destruction. However, cities and communities can treat nature positively. This can include supporting pollinators, such as providing nesting sites; ecosystem

In the U.S., the construction and demolition of our buildings accounts for 165 million tons of waste annually. Using the average volume of municipal solid waste of 225 pounds per cubic yard, that equates to 39.4 billion cubic feet every year. If we were to dump this year's building waste on top of Seattle, it would look like this:



[112] It is not entirely clear exactly how much resource extraction is due to the construction industry, and estimations range between 50 to 75 percent. See for example: Grecia Matos and Lorie Wagner, "Consumption of Materials in the United States, 1900–1995," U.S. Geological Survey, 1995, https://pubs.usgs.gov/annrev/ar-23-107/aerdocnew.pdf. ; Tarja Häkkinen and Antti Ruusk , "Material Efficiency of Building Construction," VTT Technical Research Centre of Finland, 2014, https://www.researchgate.net/publication/264859687_Material_Efficiency_of_Building_Construction.

[113] Sumit Chakravarty, S. K. Ghosh, C. P. Suresh, A. N. Dey and Gopal Shukla, "Deforestation: Causes, Effects and Control Strategies," in Global Perspectives on Sustainable Forest Management ed. Okia Clement Akais, (April, 2012), https://www.chathamhouse.org/sites/files/chathamhouse/events/special/Mining_workshop_summary_final.pdf.

[114] "Living Beyond Our Means," Millennium Ecosystem Assessment Board, 2005, http://lib.riskreductionafrica.org/bitstream/handle/123456789/466/living%20beyond%20our%20means.%20natural%20assets%20and%20human%20well-being.pdf?sequence=1; Bruno Locatelli and Emilia Pramova, "Forests and Adaptation to Climate Change: What is at Stake?" Center for International Forestry Research, accessed December 14, 2017, https://www.wri.org/node/40263.; Jens Abildtrup et al. "The Provision of Ecosystem Services," What Science Tells Us, ed.Bo Jellesmark Thorsen, Robert Mavsar, Irina Prokofieva, Anne Stenger, and Liisa Tyrvalnen, 2014. https://www.efi.int/publications-bank/provision-forest-ecosystem-services-assessing-cost-provision-and-designing.

[115] Amanda Wills, "The Lowdown on Landfills," Earth911, March 30, 2009, http://earth911.com/eco-tech/the-lowdown-on-landfills/.

[116] King, "Confronting."

[117] Jesus Campos, Sergio Jimenez, and Wilver Salinas, "Impacts Of Urbanization On Coastal Zones. Case Study: Altamiramadero-Tampico Conjoined Area, Tamaulipas, Mexico," Harte Research Institute, accessed December 14, 2017, https://www.harteresearchinstitute.org/sites/default/files/inline-files/13.pdf.; "Climate Impacts on Coastal Zones," United States Environmental Protection Agency, accessed December 14, 2017, https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-coastal-areas_.html.

[118] Nirmala George, "India Gives Ganges, Yamuna Rivers Same Rights as a Human," Associated Press, March 21, 2017, https://apnews.com/5d7848a2e3ad42c596df1d006702906f.

services, such as groundwater recharge; and native species' habitat, such as protected status for threatened trees. The Yellowstone to Yukon Conservation Initiative is a pioneering example of protecting a large migratory corridor that seeks to integrate existing settlements on a large scale.[119] Furthermore, natural resources are shipped around the globe for building housing, which leads to both greenhouse gas emissions that exacerbate climate change and the concentrated impact of resource extraction on particular regions. Materials should be easily locally produced or sourced with a focus on reuse to reduce this impact. Further, virgin materials should blend easily with the retrofit of existing homes in order to improve reuse and resource efficiency.

The following system failures are key contributors to this problem:

- The cost of waste is artificially low. Construction waste and pollution are classic economic externalities wherein the actual cost to civilization is not incurred by those that are disposing of such waste.
- Little technological innovation in building materials has led to a building industry that uses materials in a way that is inefficient and antiquated.
- Construction standards that promote novel materials or the reuse of materials are either nonexistent or woefully outdated in much of the world. This results in standards followed by architects and builders that do not incorporate new approaches or environmentally sustainable practices.
- Construction practices and urban planning rarely take into account the local conditions, like available resources and climate. As a result, many growing cities are building inefficient urban dwellings that place excessive pressure on natural habitats both locally and across the globe where resources are extracted.

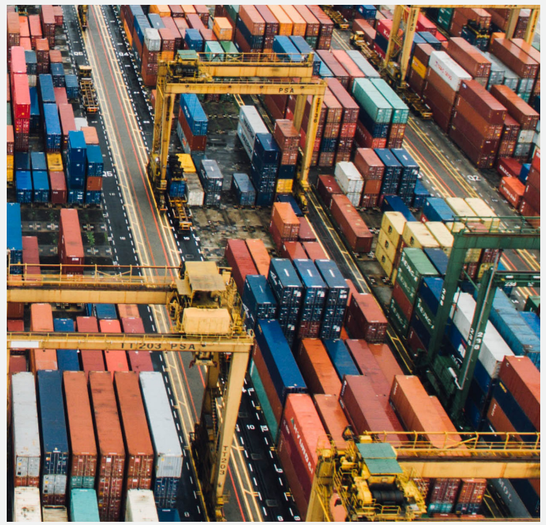
SNAPSHOT FROM THE CURRENT STATE: NEW ENGLAND IN THE DESERT

KEY USER LENS:

- **The New Middle**
- **Affluent and Savvy**
- **Elderly and Infirm**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• Closed loop homes that produce their own energy, reuse waste, and water. • New materials that can capture, store, and disseminate energy. • AI-driven architectural design that will design communities using natural materials and factoring in the weather conditions of the place of construction.
MARKETS	• Housing incubator spaces that are capable of displaying new building materials and housing technologies that work, so that both the public and governments can observe and make decisions to integrate these technologies (policy changes, commercial adoption, etc.).
POLICY	• Change in building codes that allow for rapid inclusion of new materials in the construction process.



Wealthy nations make efficient use of resources within their own territories, but they also exploit the resources of the rest of the world in the form of raw materials used to make the products they import. According to a 2008 study, about 40 percent of all raw materials consumed around the world were used to manufacture exported goods—some 70 billion tons of raw material, all told.[120] The amount of materials used for the manufacture of products imported by the rich countries far exceeded the contents of the products these wealthy nations ultimately purchased in the form of imports. The most common example is metal, which is imported in bulk in its purer form, rather than as ore from which the importing countries then have to extract the metal themselves.[121]

In the U.S., more states are passing laws that require the recycling of goods, especially electronics (e-waste). Because the U.S. places fewer restrictions on trash exports and monitors them less than Europe, that increasing volume of recycled goods is flowing relatively freely overseas, mostly legally. Up to 100 containers of waste from the U.S. are sent overseas each day, according to environmental groups and local authorities.[122]

The Western ideal of housing is often related to big, green yards with wooden single-family homes. However, given the vulnerability of its habitat, the industrialized West will continue to export its construction waste to less developed countries (e.g., Mexico, Africa). This trend is expected to escalate, with the growing quantities of e-waste, including in the context of the new connected-homes and the extensive use of information-technology-related tools in construction.[123]

In countries such as the U.S., desirable housing developments will often consist of these large-lot, single-family homes. These developments exist regardless of natural context or regionally available materials, leading to inefficiencies in building-type, energy and water use, as well as land consumption. Furthermore, these approaches tend to ignore both climate and natural habitats, leading to large resource use and destruction as well as ecosystem fragmentation. By building without regard to the natural environment, housing developments can lead to massive environmental destruction.

[119] "Home," Yellowstone to Yukon Conservation Initiative, accessed December 14, 2017, https://y2y.net.
[120] Keiichiro Kanemoto, Manfred Lenzen, Daniel Moran, Heinz Schandl, Sangwon Suh, James West, and Thomas O. Weidmann, "The Material Footprint of Nations," Proceedings of the National Academy of Sciences of the United States of America 112, no. 20, ed. Joan Martínez Alier, August 1, 2013, http://www.pnas.org/content/112/20/6271.full.
[121] Kanemoto, "The Material."
[122] Elisabeth Rosenthal, "Smuggling Europe's Waste to Poorer Countries," The New York Times, September 26, 2009, https://www.nytimes.com/2009/09/27/science/earth/27waste.html.
[123] John Vidal, "Toxic 'E-Waste' Dumped in Poor Nations, Says United Nations," The Guardian, December 14, 2013, https://www.theguardian.com/global-development/2013/dec/14/toxic-ewaste-illegal-dumping-developing-countries.

PART II: OUR CURRENT TRAJECTORY

THE GLOBAL MEGA-TRENDS

The grand challenge, and the problems and system failures associated with it, are likely to be exacerbated by a number of global mega-trends. These trends transcend housing, but are poised to affect it in fundamental ways—some positive, but mostly in ways that will carry us further away from achieving adequate or desirable housing around the globe. The most significant global mega-trends are described in more detail below; each aligns with the six problems described in Part I:

- Demographics: The overall population is growing—and concentrating rapidly in urban areas.
- Affordability: The economic divide, driven by globalization among other factors, is proliferating around the globe and growing wider.
- Technology: We are in the midst of a Fourth Industrial Revolution, wherein technologies are emerging and transforming our world at an unprecedented pace and scale.
- Adaptability: Demographics and the different ways people want to live are evolving.
- Resilience: Climate change will demand greater resiliency to balance the needs of communities with preservation of the planet.
- Environment: Global climate is projected to continue to change over this century and beyond. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases emitted globally, and how sensitive the earth's climate is to those emissions.

DEMOGRAPHICS

The overall population is growing—and concentrating rapidly in urban areas.

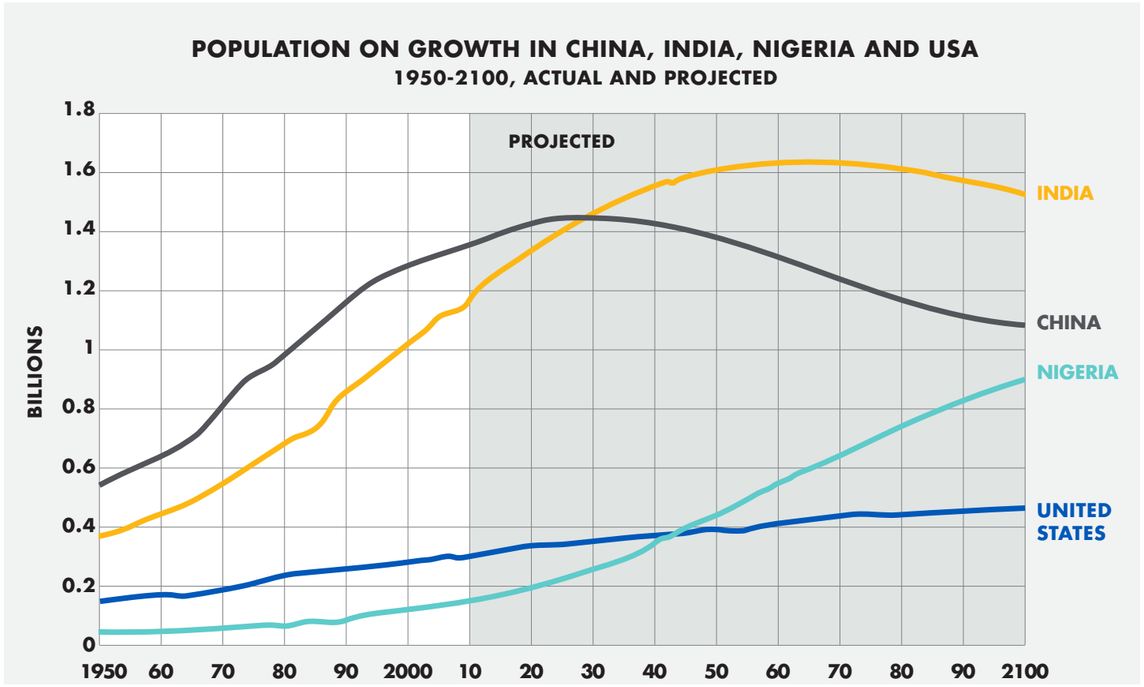
The global population is growing by just over 1 percent annually, or 83 million people. The world's population is projected to increase from 7.4 billion in 2017 to 8.6 billion in 2030 to 9.8 billion in 2050.[124] Over this same period, half of the world's population growth will be concentrated in just nine countries (in descending order of growth): India, Nigeria, Democratic Republic of the Congo, Pakistan, Ethiopia, the United Republic of Tanzania, the United States, Uganda, and Indonesia. Nigeria is already the fastest-growing country in the world and is on pace to surpass the U.S. to become the third largest country in the world shortly before 2050 (see Figure 9).[125]

Much of this population growth is due to high birth rates in the developing world. The 47 least developed countries (LDCs) in the world continue to have a relatively high level of fertility—4.3 births per woman between 2010

[124] "World Population Prospects," United Nations, 2017, https://esa.un.org/unpd/wpp/Publications/Files/WPP2017_KeyFindings.pdf.
[125] "United Nations, "World Population."

and 2015—resulting in rapid population growth of about 2.4 percent annually.[126] In a few cases, such as in the U.S., projections of population growth are related to increased immigration and lower mortality rates.[127]

FIGURE 9: ACTUAL AND PROJECTED POPULATION GROWTH IN SEVERAL COUNTRIES[128]



AFFORDABILITY

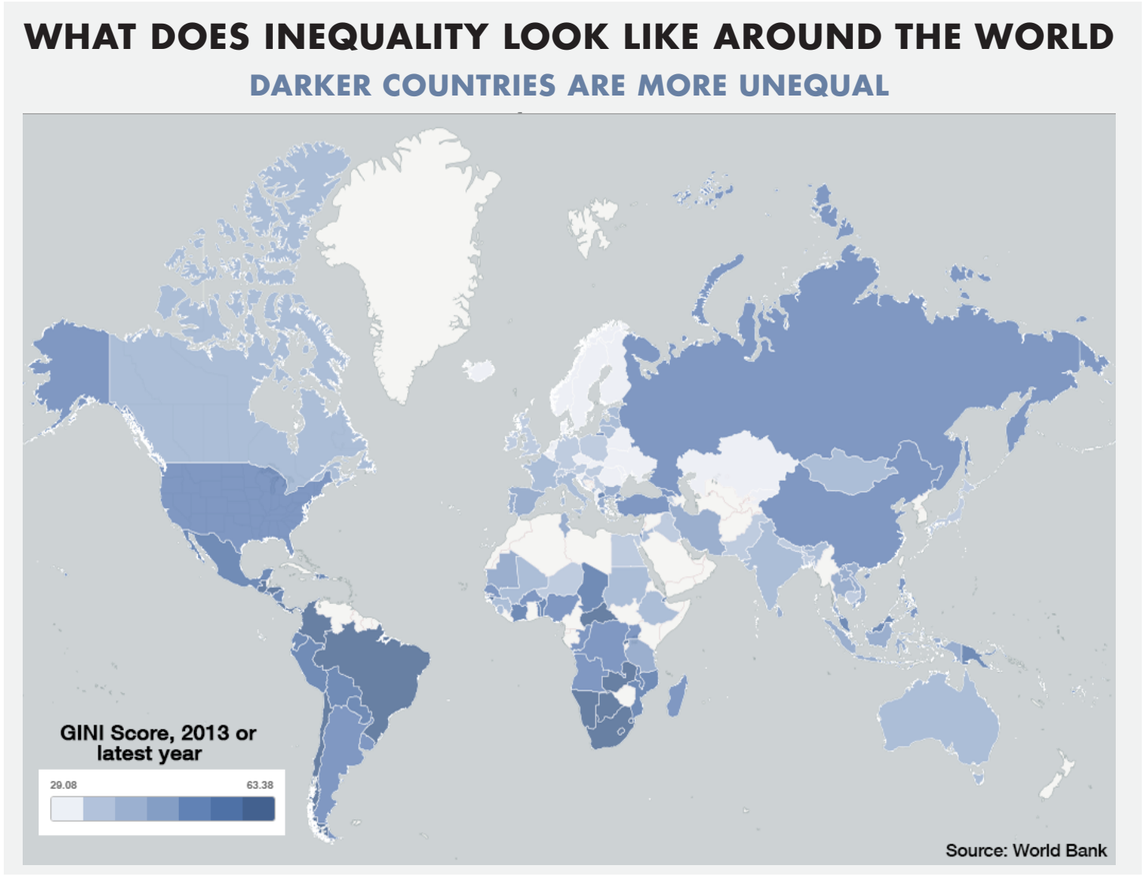
The economic divide, driven by globalization among other factors, is proliferating around the globe and growing wider.

The gap between the rich and poor is reaching new extremes. Credit Suisse, a financial services company, recently reported that the wealthiest 1 percent have accumulated more wealth than the rest of the world combined.[129] Moreover, the wealth owned by the poorest half of the world's population has fallen by $1 trillion in the past five years.[130] In 2015, just 62 individuals had the same wealth as the 3.6 billion people who represent the poorest half of the global population.[131] Since the turn of the century, they have received just 1 percent of the total increase in global wealth.[132] While levels of inequality vary widely throughout the world, some of the most developed countries in the world boast some of the highest levels of wealth and income inequality (see Figure 10).

TECHNOLOGY

We are in the midst of a Fourth Industrial Revolution, wherein technologies are emerging and transforming our world at an unprecedented pace and scale.

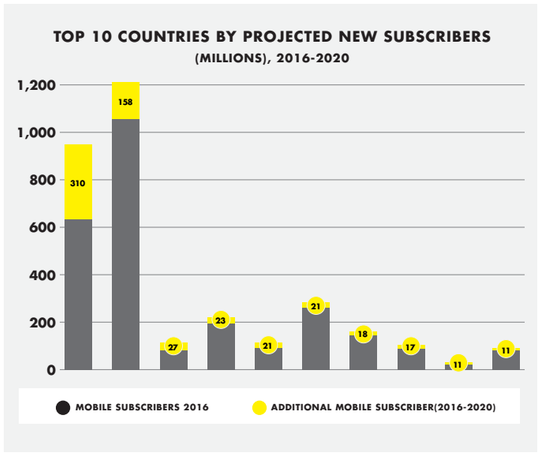
FIGURE 10: GLOBAL ECONOMIC INEQUALITY[133]



The Third Industrial Revolution, which we have experienced for several decades now, has been one in which digital technologies have democratized access to information and accelerated automation. Today, data is everywhere. Ninety percent of all the data in the world has been generated over the last two years.[134] And moreover, a growing portion of people around the world has access to it. By 2020, almost three quarters of the world's population (5.7 billion people) will subscribe to mobile services, which is the most common way of accessing the Internet in the developing world.[135] Between 2016 and 2020, ten countries—India, China, Nigeria, Indonesia, Mexico, U.S., Brazil, Pakistan, Myanmar, Bangladesh—will account for 72 percent of growth in new mobile subscribers worldwide (see Figure 11), with lower data tariffs and cheaper smartphones key to increased uptake.[136]

[126] "United Nations, "World Population."
[127] "International Migration Is Projected to Become Primary Driver of U.S. Population Growth for First Time in Nearly Two Centuries," United States Census Bureau, May 15, 2013, https://www.census.gov/newsroom/press-releases/2013/cb13-89.html.
[128] "UN: India to Be World's Most Populous Country by 2028," BBC, June 14, 2013, http://www.bbc.com/news/world-asia-22907307.
[129] "An Economy for the 1 Precent," Oxfam, January 18, 2016, https://www.oxfam.org/sites/www.oxfam.org/files/file_attachments/bp210-economy-one-percent-tax-havens-180116-en_0.pdf.
[130] Oxfam, "An Economy."
[131] Oxfam, "An Economy."
[132] Oxfam, "An Economy."
[133] Joe Myers, "5 Maps on the State of Global Inequality," World Economic Forum, November 25, 2015. https://www.weforum.org/agenda/2015/11/5-maps-on-the-state-of-global-inequality/.
[134] Åse Dragland, "Big Data, For Better or Worse: 90 Percent of World's Data Generated Over Last Two Years," Science Daily, May 22, 2013, https://www.sciencedaily.com/releases/2013/05/130522085217.htm.
[135] "The Mobile Economy 2017," GMSA, 2017, https://www.gsmaintelligence.com/research/?file=9e927fd6896724e7b26f33f61db5b9d5&download.
[136] Pavel Marceux, "Half the World's Population will be Online by 2030," Euromonitor International, April 26, 2015, http://blog.euromonitor.com/2015/04/half-the-worlds-population-will-be-online-by-2030.html.

FIGURE 11: TOP COUNTRIES BY MOBILE SUBSCRIBERS[137]



On top of these trends is the emergence of what the World Economic Forum is calling a Fourth Industrial Revolution, wherein a fusion of technologies is "blurring the lines between the physical, digital, and biological spheres."[138] A key element of the Fourth Industrial Revolution is velocity of change, which is happening at an exponential, rather than linear, pace.[139] Emerging technology breakthroughs in fields such as AI, robotics, the IOT, autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, and quantum computing are primed to disrupt nearly every industry in every country and at an unprecedented pace. Demographics and the ways people want to live are evolving.

Two demographic trends are particularly relevant—trends affecting aging populations and the young.

The number of persons globally aged 60 or above is expected to more than double between 2017 and 2050, rising from 962 million in

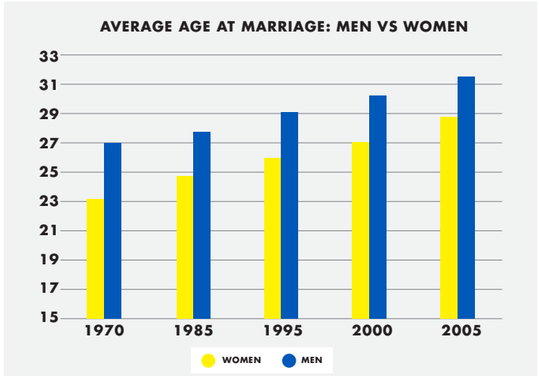
ADAPTABILITY

2017 to 2.1 billion in 2050. Sixty-five percent of the global increase will occur in Asia, 14 percent in Africa, 11 percent in Latin America and the Caribbean, and the remaining 10 percent in other regions.[140]

This trend is often explained in terms of the support ratio or dependency ratio, defined as the number of persons aged 20 to 64 divided by the number aged 65 or over.[141] Therefore, populations with low support ratios represent a larger proportion of older individuals. Currently, Japan has the lowest support ratio—2.1—but nine European countries also have support ratios below three. By 2050, seven countries in Asia, 24 in Europe, and five in Latin America and the Caribbean are expected to have support ratios below three.[142] Many of these countries with low ratios are expected to face significant barriers when it comes to the policies and costs surrounding public systems of health care, pensions, and social protections for an increasingly aging population.

Another significant trend is the delay of marriage and the extension of single, and often mobile, life. Men and women are getting married later in every region of the world. The average age of marriage for women increased from 21.8 in the 1970s to 24.7 years in the mid 2000s, with the average age for men rising a comparable amount (see Figure 12).[143] As the single population grows and the number of nuclear families decreases, the desire for increased mobility and flexible living arrangements is on the rise.

FIGURE 12: AVERAGE AGE AT MARRIAGE[144]



RESILIENCE

Climate change will demand greater resiliency to protect natural resources and balance the needs of communities with preservation of the planet.

The effects of climate change are expected to increase in the coming decades. There are various projections for the increase in global temperatures, depending on future greenhouse gas emissions, and whether they can be stabilized, reduced, or continue to grow.[145] The 2016 Paris Agreement focused on keeping global emissions from rising to a level that would result in a temperature increase above 2 degrees Celsius; however, the agreement is nonbinding, and some reports have indicated that additional action may be needed to achieve this moderate goal.[146]

Regardless of its severity, climate change will likely have several important impacts on housing. At the macro level, housing is a major driver of deforestation, mining, and water consumption. Buildings account for an estimated 24 percent of global raw material extraction.[147] Additionally, construction waste accounts for approximately 15-30 percent of all urban waste, and is often difficult to recycle due to the heterogeneity of materials used in the building process. The inefficiencies in the construction industry manifest themselves in the form of both waste and emissions. In the U.S., some estimates suggest that the building industry consumes nearly half of the country's energy and produces 45 percent of its greenhouse gas emissions.[149]

At the individual level, homes will need to be able to withstand more extreme environments — heat, cold, wind, water, and fire. Many people today, certainly in wealthier countries, take the idea of shelter for granted, but as the planet warms, that may no longer be the case. Places that have never experienced extreme drought or floods may be subject to them frequently. Places where storms, such as hurricanes, are already prevalent may see more severe events.[150]

[137] GSMA, "The Mobile."
[138] Klaus Schwab, "The Fourth Industrial Revolution: What it Means, How to Respond," World Economic Forum, January 14, 2016, https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/.
[139] Schwab, "The Fourth."
[140] United Nations, "World Population."
[141] United Nations, "World Population."
[142] United Nations, "World Population."
[143] "World Marriage Data 2015," United Nations Department of Economic and Social Affairs, 2015, http://www.un.org/en/development/desa/population/theme/marriage-unions/WMD2015.shtml
[144] Alex Mayyasi, "At What Age Do People Get Married Around the World?" Pricenomics, November 2, 2013, https://priceonomics.com/at-what-age-do-people-get-married-around-the-world/.
[145] "Projections of Future Changes in Climate," Intergovernmental Panel on Climate Change, 2007, https://www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-projections-of.html.
[146] David Roberts, "It's Time to Start Talking About 'Negative' Carbon Dioxide Emissions," Vox, August 18, 2017, https://www.vox.com/energy-and-environment/2017/8/18/16166014/negative-emissions.
[147] Alfonso Aranda-Usón, Antonio Valero, and Ignacio Zabalz, "Life Cycle Assessment of Building Materials: Comparative Analysis of Energy and Environmental Impacts and Evaluation of the Eco-Efficiency Improvement Potential," Fuel and Energy Abstracts, (May 2011): 1133-1140, https://www.researchgate.net/publication/251576275_Life_cycle_assessment_of_building_materials_Comparative_analysis_of_energy_and_environmental_impacts_and_evaluation_of_the_eco-efficiency_improvement_potential.
[148] Claudia De Cesare, Carlos T. Formoso, Eduardo L. Isatto, and Lucio Soibelman, "Material Waste in Building Industry: Main Causes and Prevention," Journal of Construction Engineering and Management 128, no. 4 (August 2002): 316-325.
[149] "Why the Building Sector," Architecture 2030, accessed December 14, 2017, http://architecture2030.org/buildings_problem_why/.
[150] "The Impact of Climate Change on Natural Disasters," NASA, accessed December 14, 2017. https://earthobservatory.nasa.gov/Features/RisingCost/rising_cost5.php.

> Not every city can become some sort of sci-fi future version of [a city] especially when they're unprecedentedly massive, and they shouldn't... the better moonshot might be the let's-use-land-differently moonshot... It's far more efficient and possibly far less wasteful and painful to consider a shrinking-first approach to redesigning the countless ways our built environment contradict the edicts of nature.

—Patrick Stowe Jones, IA Collaborative, as posted on Floating Knowledge

ENVIRONMENT

Natural resources, including those used in housing, are rapidly dwindling due to human consumption. Extinction and the loss of ecosystem services are also accelerating, leading to a global ecological crisis that impacts communities. This will result in climate changes, which in turn will negatively impact natural resources.

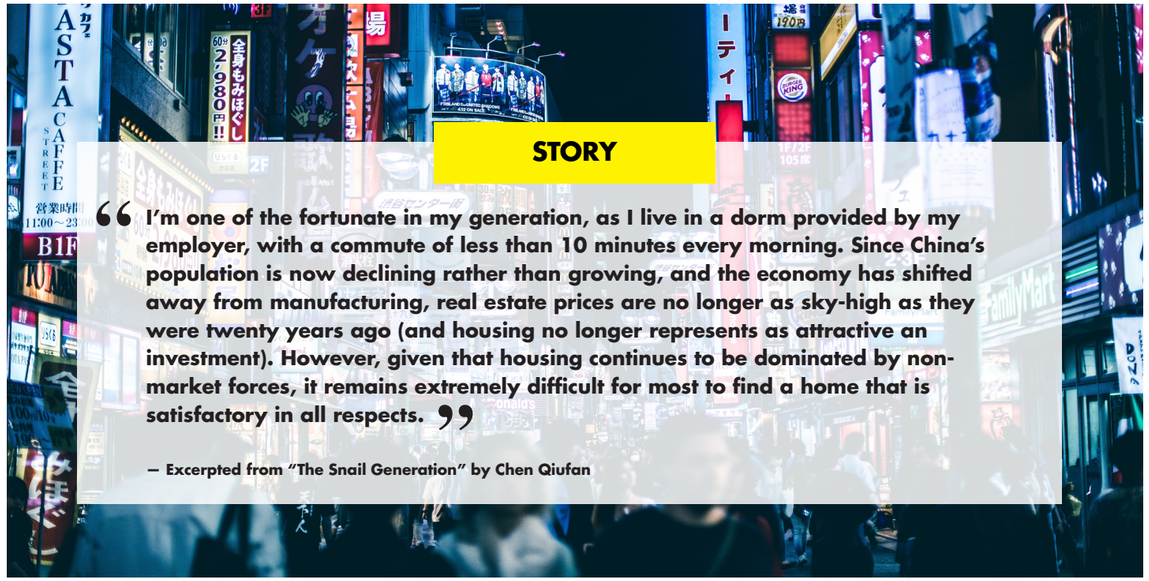
Some of the effects of climate change, predicted by scientists in the past, are now occurring: loss of sea ice, accelerated sea level rise, and longer, more intense heat waves.

Global climate is projected to continue to change over this century and beyond. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases emitted globally, and how sensitive the earth's climate is to those emissions. As climate change takes hold, there is an ever-growing need to develop and apply strategies that optimize the use of natural resources, both on land and in water.

Some of the most imminent threats from climate change will directly affect housing. This also means that the ability of humans to adapt to climate change will depend on how we build our homes and communities. Sea-level rise already impacts coastal houses and cities. Local governments have responded to this change with rolling easements, where property lines shift landward with rising seas, and new infrastructure, like seawalls, to protect vulnerable buildings.

Rising temperatures are also a looming threat. A recent study indicated that, due to increased temperatures, much of the Indian subcontinent will become so hot by 2100 that it will be uninhabitable.[151] This puts tremendous pressure on us to both create more solutions for cooling that are sustainable as well as building techniques that appropriately acknowledge this new climate.

THE FUTURE WITHOUT A DISRUPTION



STORY

> I'm one of the fortunate in my generation, as I live in a dorm provided by my employer, with a commute of less than 10 minutes every morning. Since China's population is now declining rather than growing, and the economy has shifted away from manufacturing, real estate prices are no longer as sky-high as they were twenty years ago (and housing no longer represents as attractive an investment). However, given that housing continues to be dominated by non-market forces, it remains extremely difficult for most to find a home that is satisfactory in all respects.

– Excerpted from "The Snail Generation" by Chen Qiufan

XPRIZE imagined what the future of housing could look like in the next generation if the global mega-trends discussed were to continue without disruption. Below are snapshots of what the future might look like without action. These snapshots are organized according to the same six themes discussed in the sections addressing the grand challenge and global mega-trends: demographics, affordability, technology, adaptability, resilience, and environment

DEMOGRAPHICS[152]

- Over the next 25 years, more than 2 billion people will add to the growing demand for housing. This will require completing more than 96,000 housing units per day or 4,000 housing units per hour.
- Cities will be in danger of failing to keep pace with housing demand and, as a result, may face increasing informal housing settlements, slums, and homelessness.
- Some places will pursue so-called "mega-projects" to create more housing opportunities in dense urban centers, but many will be oriented around the most affluent, like the Kingdom Tower proposed in 2011 in Jeddah, Saudi Arabia or the Sky Mile Tower in Tokyo, Japan proposed in 2016.

[151] Eun-Soon Im, Elfatih A. B. Eltahir, and Jeremy S. Pal, "Deadly Heat Waves Projected in the Densely Populated Agricultural Regions of South Asia," Journal of Science Advances 3, no. 8 (August 2017), http://advances.sciencemag.org/content/3/8/e1603322.

[152] "Fact and Figures About Financing Urban Shelter," United Nations Habitat, September 12, 2005, https://unhabitat.org/wp-content/uploads/2005/11/GRHS05L2.pdf.; King, "Confronting."; Asma Alsharif, "Saudi Billionaire to Build World's Tallest Tower," Reuters, August 2, 2011,https://www.reuters.com/article/us-kingdom-tower/saudi-billionaire-to-build-worlds-tallest-tower-idUSTRE77126520110802.; Talia Avakian, "The Next Tallest Building in the World Could Be in Tokyo—Here's What it Would Look Like if Built," Business Insider, February 16, 2017, http://www.businessinsider.com/the-next-tallest-building-could-be-in-tokyo-2016-2.

AFFORDABILITY

- Housing in cities, where land is at a premium, will continue to get more expensive for everyone.

- Vacant housing units will become vacant cities. China, which in 2017 already had an estimated 50-60 million vacant housing units, will become a country of ghost cities, where entire new cities are built up but ignored or abandoned by the intended residents.

- The young and aspirational, particularly in the developing world, will struggle to participate in homeownership, though new economic and financial models for accessing housing will continue to emerge. Chototel, a U.K.-based hotel model, will surpass its goal to build 5 million high-tech,[153] budget hotel rooms worldwide, which will charge as little as $2 per night for rooms with closed-loop utility systems; pay-per-use Internet access and utilities; and a shower, toilet, and pantry.

TECHNOLOGY

- Many new buildings will be designed and built for integration of smart home devices. However, the costs of the devices will still make them inaccessible for retrofits and lower-income housing.

- There will be an increased awareness about the building technique known as

Source: http://thequietus.com/articles/17799-ghost-cities-of-china-wade-shepard-psychogeography-economics

prostruction, which seeks to create a symbiotic relationship between the human body and the buildings they inhabit. However, critical barriers such as negative perceptions of integrated biosensing technologies and a lack of investment capital to catalyze growth have stalled the progress of these healthy homes.

- The first factories to produce modular, easy-to-assemble housing will begin to open in the U.S. and Europe. Each will be vying for the moniker "the Tesla of Homebuilding," first coined by the 2016 podcast, "Predicting Our Future."[154]

ADAPTABILITY

- The young and aspirational will have moved to smaller cities and towns to live in more affordable communities while working remotely on projects based all across the globe.[155]

- While retirement communities continue to be the housing of choice for aging affluent and savvy individuals, other elderly and infirm people, particularly those who require some level of daily care and support, have embraced a return to multigenerational living and joint family living arrangements, which utilize the space available in older, larger homes more efficiently.

- The iGen generation has embraced co-living arrangements even more strongly than their millennial predecessors, particularly in the biggest metropolitan areas where affordable rentals—let alone homeownership opportunities—are virtually nonexistent. Their grandparents refer to the arrangements as "benign communes." For the current generation, they have become the new normal.[156]

> **"They were once strangers. Online networks made them friends, and living together makes them more like family. After dinner, in keeping with the one rule of giant co-living houses, someone will do all of the dishes."**
>
> **—Elise Hu, "Bay Area's Steep Housing Costs Spark Return To Communal Living"**

RESILIENCE

- New standards and requirements for resiliency will be adopted by the wealthiest cities and benefitting the affluent and savvy, but will largely bypass poorer areas, particularly slums and rural areas. These communities will continue to be impacted the most by climate change and will be the least resilient to increasing natural disasters. This will result in large climate migrations of refugees and slum dwellers seeking sanctuary in more established and resilient cities.

- Materials at risk from being depleted—through practices such as deforestation, large scale mining for granite and natural stone, water depletion in the manufacturing of concrete—will remain less expensive than emerging sustainable alternatives like engineered wood and green concrete because of regulatory barriers.

- The number of people around the globe facing water insecurity will grow to 5.4 billion—two out of every three people. [157]

[153] "Chototel: The Peoples' Hotel," Chototel, accessed December 15, 2017, http://www.chototel.co.uk/.
[154] Andrew Weinreich, "Predicting Our Future," The Future of Homebuilding, 2016, https://www.predictingourfuture.com/homebuilding/.
[155] Derek Thompson, "Why So Many Americans Are Saying Goodbye to Cities," The Atlantic, April 4, 2017, https://www.theatlantic.com/business/archive/2017/04/why-is-everyone-leaving-the-city/521844/.
[156] Elise Hu, "Bay Area's Steep Housing Costs Spark Return To Communal Living," NPR, December 19, 2013, https://www.npr.org/sections/alltechconsidered/2013/12/19/250548681/bay-areas-steep-housing-costs-spark-return-to-communal-living.
[157] "International Decade for Action 'Water for Life' 2005-2015," United Nations Department of Economic and Social Affairs, November 24, 2014, http://www.un.org/waterforlifedecade/scarcity.shtml.

- In cities facing the challenge of rising sea levels, new types of urban development projects, like the 5 Lagoons Project, or infrastructural megaprojects, such as the North Sea Delta Works, will become increasingly attractive to investors.[158]

ENVIRONMENT

- We will face the world's sixth mass extinction—the worst in history. Researchers talk of "biological annihilation" as billions of populations of animals have been lost in recent decades, and will continue to decline in the future.[159]

- Pollution will continue to damage human health. Exposure to air pollutants has been linked to suppressed lung growth, asthma, heart disease, fetal brain growth damage, and the onset of diabetes.

- Ecosystem services will become so degraded that we must pay for artificial solutions to produce things like clean water and clean air.

- Temperatures will continue to rise. Because human-induced warming is superimposed on a naturally varying climate, the temperature rise has not been, and will not be, uniform or smooth across the all regions or over time.

- The frost-free season and growing season will lengthen. In a future in which heat-trapping gas emissions continue to grow, increases of a month or more in the lengths of the frost-free and growing seasons are projected across most of the U.S. by the end of the century.[160] This will increase the demand for better housing isolation and better heating systems, which themselves negatively affect climate change.

- Precipitation is expected to increase in higher latitudes and decrease in areas closer to the equator. Too little or too much water can cause problems. In many places, people depend on rain and snowmelt to fill lakes and streams that provide a source of water for drinking, watering crops, and other uses. However, heavy rain can cause flooding.

- More droughts and heat waves are also expected. Across the globe, hot days are getting hotter and more frequent, while we're experiencing fewer cold days. By midcentury, if greenhouse gas emissions are not significantly curtailed, scientists expect 20 record highs for every record low.[161] Extreme heat can increase the risk of other types of disasters, like droughts. This, in turn, can encourage more extreme heat, as the sun's energy acts to heat the air and land surface, rather than to evaporate water. Hot, dry conditions also increase the risk of wildfires.

- Hurricanes and tropical cyclones will become stronger and more intense. The impact of tropical cyclones on developing countries can be significant in terms of the detrimental aspects. Although loss of life from tropical cyclones has significantly decreased over recent years, especially in the developed countries, the loss of property has increased substantially. Reductions in fatalities are usually attributed to improvement in the tropical cyclone forecasting and warning system, while increases in property losses are attributed to accelerated property development in coastal zones.

- Sea level will rise 1-4 feet by 2100. When sea levels rise rapidly, as they have been doing, even a slight increase can have devastating effects on coastal habitats. As seawater reaches farther inland, it can cause destructive erosion; wetland flooding; aquifer and agricultural soil contamination; and loss of habitat for fish, birds, and plants. When large storms hit land, higher sea levels mean bigger, more powerful storm surges that can strip away everything in their path. In addition, hundreds of millions of people live in areas that will become increasingly vulnerable to flooding. Higher sea levels would force them to abandon their homes and relocate. Low-lying islands could be submerged completely.

- The Arctic is likely to become ice-free. Physical implications, which arise from lesser ocean surface covered by sea-ice, include the ice-albedo feedback or warmer sea surface temperatures, which increase ocean heat content.[162] This, in turn, changes evaporation patterns and the polar vortex. Economic implications of ice-free summers and the decline in Arctic ice volumes include a greater number of journeys across the Arctic Ocean shipping lanes during the year.[163]

THIS FUTURE IS NOT PREFERRED

Without action, the future of housing is likely to evolve to meet the needs of only some—rather than most—of humanity. In significant parts of the world, both developed and developing countries, housing is on a trajectory to become:

- More unhealthy and vulnerable to extreme environmental disasters
- Less affordable for a greater number of people
- Static and unable to adequately meet the needs of people in different circumstances, at different stages of life
- A driver of anxiety in an increasingly crowded and complex world

This future is not only not preferred, it is unacceptable. Do you agree? If so, read on to Part III.

[158] Debra Black, "Floating Islands to the Rescue in the Maldives," The Star, August 23, 2012, https://www.thestar.com/news/world/2012/08/23/floating_islands_to_the_rescue_in_the_maldives.html.
[159] Gerardo Ceballosa, Rodolfo Dirzob, and Paul R. Ehrlichb, "Biological Annihilation Via the Ongoing Sixth Mass Extinction Signaled by Vertebrate Population Losses and Declines," Proceedings of the National Academy of Sciences of the United States of America 114, no. 3, ed. Thomas E. Lovejoy and Peter H. Raven (March 2017), http://www.pnas.org/content/114/30/E6089.
[160] "The Consequences of Climate Change," NASA, accessed December 14, 2017, https://climate.nasa.gov/effects/
[161] https://www.c2es.org/content/heat-waves-and-climate-change/.
[162] Peter Wadham, A Farewell to Ice: A Report From the Arctic (U.K.: Penguin Press, 2016), 4.
[163] "The Great Energy Challenge," National Geographic, accessed November 29, 2016, http://environment.nationalgeographic.com/environment/energy/great-energy-challenge/arctic-map/.

PART III: AN ALTERNATIVE FUTURE

A PREFERRED FUTURE STATE

The future described above is certainly not a given. We can address grand challenges and system failures to leverage, shift, or even reverse trends—even global mega-trends—by enabling and incentivizing bold actions.

However, to truly think boldly, we cannot start with today. We must start with a preferred future state.

Imagine a future where, within a generation, safe, healthy, and desirable housing will be accessible so that everyone can feel at home in a changing world.

Each aspect of the preferred future state is described in more detail as part of the narratives and scenarios below.

SNAPSHOTS FROM THE FUTURE

We illustrated the preferred future state by using a simplified version of an approach pioneered by Royal Dutch Shell in the 1960s, originally called futures planning and now typically referred to as scenario planning. Through this process, individuals and teams develop scenarios with several key characteristics:

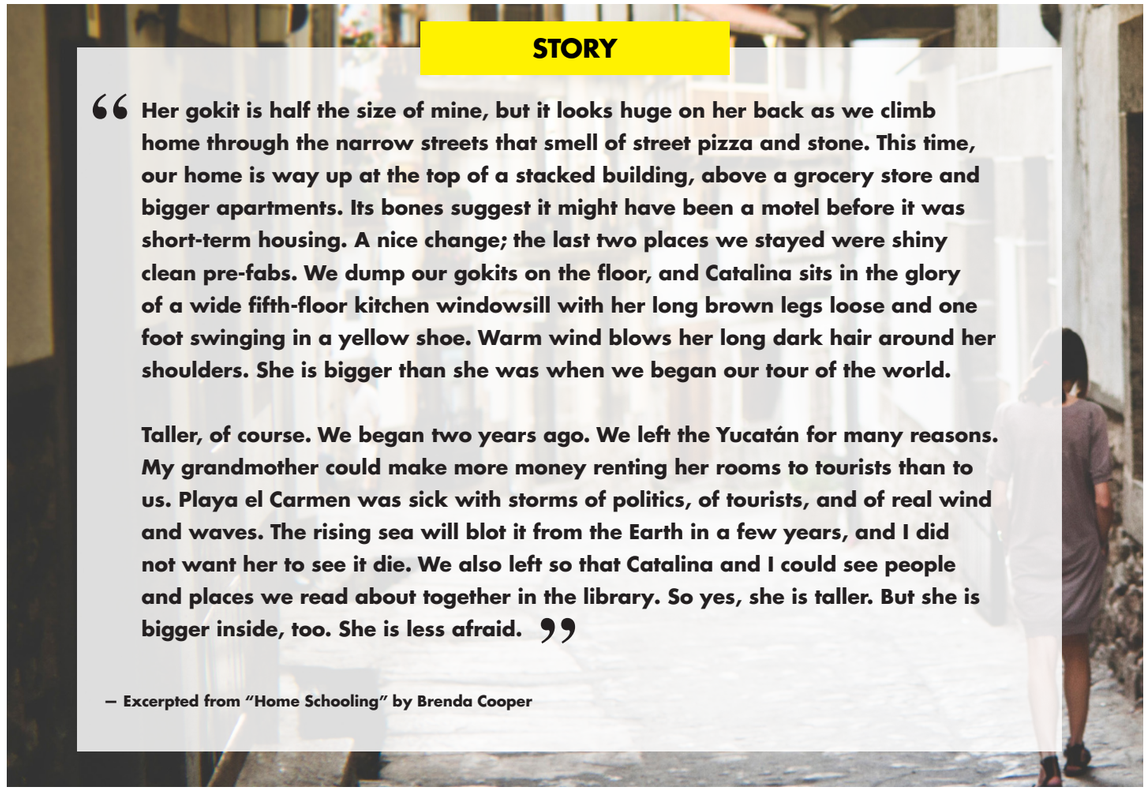
- Focused on what should or could happen
- Not inherently good or bad
- Encourage subjective judgment and intuition
- Able to include discontinuities
- Illuminated by charismatic presenters; evocative graphics; memorable phrases, images, and archetypes; illustrative graphs of future outlooks; and storytelling

Scenario planning has been found to open up new ways of thinking and aid decision-making by revealing possible futures that would

otherwise not have been imagined. Scenarios can also help show a logical chain of events that demonstrate how a future vision unfolds and, ultimately, how we can achieve or avoid it.

The following section highlights 17 snapshots representing some of the most compelling ideas from a set of approximately 75 scenarios we developed while creating the Housing Futures ImpactMap. These snapshots are organized into narratives that comprise the concepts—safe and healthy; accessible; desirable; and feeling at home in the world—identified in our preferred future state.

But to begin, here is a story…



STORY

"Her gokit is half the size of mine, but it looks huge on her back as we climb home through the narrow streets that smell of street pizza and stone. This time, our home is way up at the top of a stacked building, above a grocery store and bigger apartments. Its bones suggest it might have been a motel before it was short-term housing. A nice change; the last two places we stayed were shiny clean pre-fabs. We dump our gokits on the floor, and Catalina sits in the glory of a wide fifth-floor kitchen windowsill with her long brown legs loose and one foot swinging in a yellow shoe. Warm wind blows her long dark hair around her shoulders. She is bigger than she was when we began our tour of the world.

Taller, of course. We began two years ago. We left the Yucatán for many reasons. My grandmother could make more money renting her rooms to tourists than to us. Playa el Carmen was sick with storms of politics, of tourists, and of real wind and waves. The rising sea will blot it from the Earth in a few years, and I did not want her to see it die. We also left so that Catalina and I could see people and places we read about together in the library. So yes, she is taller. But she is bigger inside, too. She is less afraid."

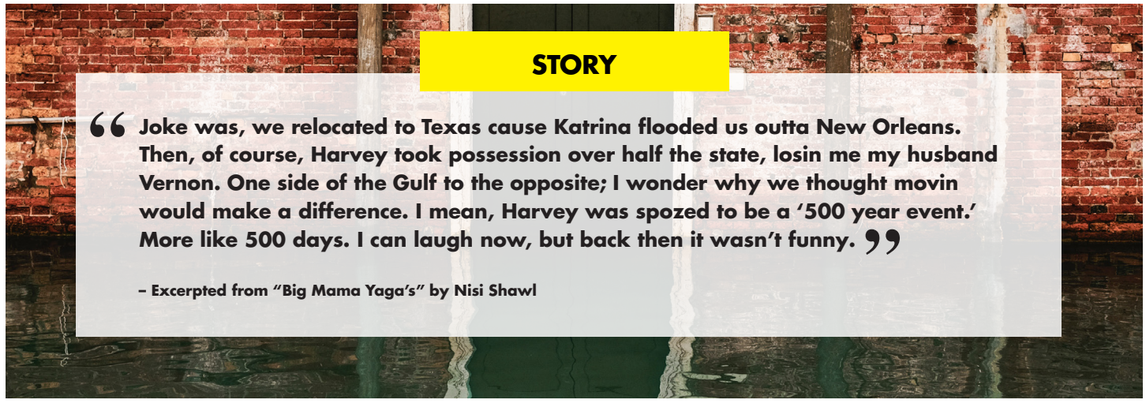
– Excerpted from "Home Schooling" by Brenda Cooper

SAFE AND HEALTHY NARRATIVE

Homes that are safe and healthy address our most basic physiological and psychological needs. In this narrative, we imagine how housing might evolve to be more resilient, energy efficient, and intelligent—and how housing itself might be a mechanism for achieving a more sustainable planet.

Scenarios that comprise this narrative:

- A House That Cares
- Shelter From the Storm
- Just Float
- Prostruction Revolution
- The Comfort of Home



STORY

"Joke was, we relocated to Texas cause Katrina flooded us outta New Orleans. Then, of course, Harvey took possession over half the state, losin me my husband Vernon. One side of the Gulf to the opposite; I wonder why we thought movin would make a difference. I mean, Harvey was spozed to be a '500 year event.' More like 500 days. I can laugh now, but back then it wasn't funny."

– Excerpted from "Big Mama Yaga's" by Nisi Shawl

A HOUSE THAT CARES

KEY USER LENS:

- **Elderly and Infirm**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• Intelligent home (AI, Sensors, Connection to Care Community)
MARKETS	• Self-healing concrete
POLICY	• Multigenerational facilities where elder care is provided by other residents • Zoning laws to enforce multigenerational developments

Since 2018, the number of people over 70 has tripled globally. Europe, Japan, and North America face increasingly unfavorable dependency ratios. However, a combination of AI, VR/AR, biomimetics, and avatar technologies are becoming standard integrations in homes for elderly and disabled people who need frequent physical care and support. The home itself can now actually take care of its residents, automatically diagnosing problems. Innovations like self-healing concrete allow structures to repair themselves, obviating the need for burdensome home maintenance. 2035 marks the first year that more individuals over 75 live at home rather than in nursing homes or other assisted care facilities.

[164] Roland Kupers and Angela Wilkinson. "Living in the Futures," Harvard Business Review, May 2013, https://hbr.org/2013/05/living-in-the-futures.

SHELTER FROM THE STORM

KEY USER LENS:

- **Refugees and Slum Dwellers**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• Mobile, self-contained pods that are easy to assemble and have sanitation needs included
MARKETS	• Repurposing old refugee camps as new city centers
POLICY	• Reducing stigma for refugees by enforcing a camp to city policy where full integration of refugees can take place in a 2-3 year period of time.

In 2035, regional and localized conflicts, as well as increasing extreme heat and drought now attributed to climate change, have made mass migration the new normal. Refugee camps—often criticized in the past as a blight on local communities, hotbeds of corruption and criminal activities, and for their squalid living environments—have been replaced with new, flexible, safe, and even attractive mobile pod-like housing units that include hook-ups for electricity and sanitation. Several companies are vying to be the leader in pod manufacturing; all adhere to global standards for sustainability, resiliency, and mobility. Most pod solutions are lightweight and easy to transport wherever populations need them. Modular construction techniques allow refugee coordinators to rapidly relocate shelters to respond to changing geographical demand.

JUST FLOAT

KEY USER LENS:

- **Affluent and Savvy**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• New sea wall to help with rising sea levels • Self-contained housing "islands"
MARKETS	• New markets for "off-shore" self-contained island living
POLICY	• New zoning laws for "off-shore" developments

In 2035, sea level rise attributed to climate change has made 20 percent of coastal cities uninhabitable. Sea levels in the Atlantic and Pacific oceans have risen 80mm, and 50 million people have become "climate refugees" from coastal cities. The first "luxury floating city" is about to open off the coast of China, near where Shanghai used to be, while scientists and engineers will soon demonstrate a new type of seawall that could save dozens of "new" coastal cities around the world.

PROSTRUCTION REVOLUTION

KEY USER LENS:

- **Affluent and Savvy**
- **Multigenerational/Multifamily**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• New materials for building that can be grown, that have the same stability and resiliency of wood and/or concrete • New investment in radical experimentation of new construction materials
MARKETS	• Education and inclusion of industry leaders, especially for retrofit industry
POLICY	• New sets of code that allow for new building materials to be integrated starting with retrofits to create fully functional hybrid buildings

In 2035, housing construction has finally shed its dubious distinction as a leader in resource depletion, environmental degradation, and unhealthy materials. Instead, our bodies and the buildings we inhabit are in a symbiotic relationship thanks to developments in synthetic biology, computational design, bio-printing, and materials engineering. Companies leveraging these developments have offered the previously stagnant construction industry a new paradigm for success as they have successfully facilitated the fusing together of the physical, the digital, and the biological to create homes that are truly net positive, both for our bodies as well as for our environment. This new archetype for construction, called "prostruction," has employed technologies like facade panels that utilize algae to generate biofuel, bricks made out of mycelium ("mushroom bricks"), and synthetic bio-detectors to address problems of personal and environmental health related to the building industry at their root, ensuring truly healthy and sustainable buildings.

THE COMFORT OF HOME

KEY USER LENS:

- **Multigenerational/Multifamily**
- **The New Middle**
- **Elderly and Infirm**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• Multiple open innovation challenges to spur new technology • Angel investment in nascent technology for the housing industry
MARKETS	• Multiple Innovation Incubators and Accelerators needed across the globe, pioneered by industry stalwarts
POLICY	• New code to adopt new technologies

Since 2018, the incidence and magnitude of extreme weather events has continued to rise. On average, every region around the globe now experiences a 100-year extreme weather event (storm, flood, drought, or fire) approximately every two years. Extreme heat affects urban areas consistently in spring, summer, and fall; cold fronts and blizzards in winter often strike large regions with little warning. However, starting about a decade ago, several countries developed standard national building codes, that have since been adopted in developed and developing countries alike. A series of annual open innovation challenges has revolutionized building materials, including insulation, HVAC systems, and materials such as self-healing concrete. In 2035, individuals and families who live in homes that meet the new national building standards no longer have to worry about the impacts of extreme weather. They can shelter in place with access to water and electricity with the knowledge that their home will protect them, even from the most dangerous events.

> "We will have to standardize housing to meet the massive demand for the world. However, while the external construction will be standard, the internal space will be hyper-personalized with the advancement of sensors, digitization and mixed reality."
>
> —Patrick Stowe Jones, IA Collaborative, as posted on Floating Knowledge

DESIRABLE NARRATIVE

Desirable means something different to just about everyone. Why can't housing evolve to meet a multitude of desires? This narrative explores how housing might become more flexible, adaptable, and able to meet a wide variety of needs, lifestyles, and communities.

Scenarios that comprise this narrative:

- Mobile, Mobile Home
- Housing as a Service
- Your Home Is Arriving Now…
- Incubating the Future

MOBILE, MOBILE HOME

KEY USER LENS:

- **The New Middle**
- **Multigenerational/Multifamily**
- **Elderly and Infirm**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• Modular pods become industry standards • AR/VR and 3D printing allow for extreme customization and adaptation to design and individual's desires
MARKETS	• Multiple levels of affordability of modular units, without sacrificing aesthetic values
POLICY	• Standardization of policy across standard features of pods

In 2035, most people have forgotten that mobile homes ever had a negative association or were considered unsafe. Small, modular homes that can be quickly and easily assembled ("like IKEA furniture", some older people say) are available to rent or own and now move with you anywhere over land or air. Mobile homes are frequently deployed for large public events, for disaster relief, and near factories and workplaces. And the factories that manufacture them now make up 1 million jobs worldwide.

HOUSING AS A SERVICE

KEY USER LENS:

- **Young and Aspirational**
- **Affluent and Savvy**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY

- Significant advances in AR/VR that minimize lenses/glasses into contact lenses for ease of use and portability
- Digital art, like music can now be purchased and projected on to walls with mini, hidden projectors that can be easily programmed for individual customization

In 2035, the hottest play in Silicon Valley is now platform-style membership programs that allow knowledge workers, creative makers, and other "gig" workers to access flexible, housing in different locations around the world. Primarily targeting the younger, upwardly mobile set, these platform communities are oriented towards meeting the needs of increasingly affluent workers who frequently change locations in pursuit of career opportunities and are seeking new friends with whom to explore the cultural, dining, and recreational amenities of urban centers. Housing units offer residents free wireless charging, VR gaming, personal chefs, and self-driving car services. Various social media apps allow arriving residents to see which of their friends are also checked in at any location. Platform companies are beginning to explore new customer niches, including membership units for families expecting their first child equipped with cribs, strollers, car seats, toys, and unlimited diapers.

YOUR HOME IS ARRIVING NOW...

KEY USER LENS:

- **Young and Aspirational**
- **Affluent and Savvy**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY

- Multi-sized, multi-use pods that can be customized through standard modular features
- Self-contained pod technology with closed loop waste, water, and energy units

MARKET

- Various price points for pods to assure affordability and not exclusivity

POLICY

- Pod parking laws and zones within city centers that allow transient pod dwellers to dwell safely and unobtrusively

"Meet you in 30. My home is arriving now, and I need to drop off my bag and grab a quick shower." In 2035, that message is now a common refrain as more business travelers order "autonomous sleeping pods" that provide a bed and basic necessities for living, including quick plumbing hookups, free WiFi, and pre-selected meals in the refrigerator. Pods typically have a footprint of 100 square feet and can be delivered to one of the new "pod parks" (repurposed parking lots and garages, which would otherwise go vacant because autonomous vehicles have replaced the need for parking in most cities) or anywhere else zoned for their use. Pods are available for as short as a night or as long as a month. Suburban and even rural communities have begun zoning residential land for pod parks around business centers and universities. One pod delivery service has started to offer larger (200 square foot) pods for longer durations (up to 1 year), hoping to attract younger and single individuals who have been priced out of traditional rental markets.

INCUBATING THE FUTURE

KEY USER LENS:

- **The New Middle**
- **Multigenerational and Multifamily**
- **Elderly and Infirm**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• Standardization and integration of smart home technologies • New incubators to help integrate existing tech and incubate new tech for smart mini-grids for homes
MARKETS	• Smart home technology becomes accessible to all
POLICY	• Increased utility tax for non-smart homes

It's 2035, and a wide range of interconnected smart home devices are now standard in all new homes—from low-income public housing to high-end luxury condos—in more than a dozen major metropolitan areas around the globe. It all started about a decade ago with a proliferation of housing technology incubator spaces. These model homes began as demonstration sites for innovators to test and experiment with new devices and, most importantly, meet other innovators with complementary solutions. Quickly these innovators began to solve interoperability and integration issues, find ways to reduce costs, and connect with supply chains. Several even combined forces to start new companies that offer packaged smart home solutions. Soon, entrepreneurs had an idea to open up the space to the public—future customers who could get a hands-on experience with the new devices, ask questions, and sign up to try them out in their own homes. Just last month, Lowe's announced a plan to replicate the incubator spaces at 50 of its mega-stores worldwide. The democratization of the smart home is here.

ACCESSIBLE NARRATIVE [165]

Housing is attainable when it's both affordable and physically accessible. This narrative explores ways that housing might be transformed and become accessible to most or all of humanity.

Scenarios that comprise this narrative:

- The Free House
- Build Me Up/Build Me Down
- The 3D Printed Neighborhood
- Transformer
- Fund My Home

[165] Richard Burns, "The Future of Affordable Housing in America," Housing Wire, August 10, 2016, http://www.nhpfoundation.org/documents/Viewpoints2%208-10-2016.pdf.

Source: http://thepipreport.com/news/black-mirror-mr-robot-perfect-responses-yesterdays-internet-outage/

THE FREE HOUSE

KEY USER LENS:

- **Refugees and Slum Dwellers**
- **Young and Aspirational**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• Cybersecurity threats eliminated by state-of-the-art, intelligent cyber-sleuths that can detect and tackle an attack as soon as it happens
MARKETS	• Lucrative markets for individuals' data
POLICY	• New laws that allow for mass data collection

Since 2018, the unstoppable rise in housing costs ultimately pushed people to give up their privacy for a free place to live. Trends in mass surveillance and social media have desensitized societies, and especially younger individuals, to the idea of constantly being monitored. Free housing communities have been developed that allow tenants to occupy a living space for no money. Instead, tenants agree to allow the homeowner or developer to closely monitor tenants around the clock to gather valuable data that can be sold for a profit. Older generations have balked and attempted to organize protests, but young and low-income individuals don't quite understand why others are so concerned.

Source: http://abcnews.go.com/blogs/technology/2012/12/bringing-sunlight-to-light-an-underground-garden/

BUILD ME UP/BUILD ME DOWN

KEY USER LENS:

- **The New Middle**
- **Affluent and Savvy**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• Modular building systems for the construction megastructures
	• Closed-loop systems for megastructures
	• New cooling technologies
MARKETS	• Market incentives for affordable megastructures, not just high-end apartments

In major urban areas, the limited supply of remaining land drives 80 percent of housing costs. In 2035, some communities have responded by creating new land—revising zoning ordinances and building codes to allow megastructures to be built above and below ground. Everything from basic to luxury services are offered within the building; skylights and VR technologies bring natural light into underground communities and windows open in even the highest buildings so that residents can enjoy the fresh air otherwise only found in the mountains. Residents often rarely leave the buildings themselves, and are beginning to create new and dynamic political and social structures unique to the building. One megastructure community in Rio de Janeiro, Brazil, has just announced it has applied to incorporate as its own city.

Source: http://www.lgm3d.com/portfolio#!project=pasabahce-neighborhood

THE 3D PRINTED NEIGHBORHOOD

KEY USER LENS:

- **Refugees and Slum Dwellers**
- **The New Middle**
- **Multigenerational and Multifamily**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• Recycled waste like plastics, form new source materials for 3D-printed homes • Large-scale 3D printing of homes made affordable through economies of scale
MARKETS	• Tax incentives from 3D-printed homes that are made from more than 50 percent waste materials
POLICY	

The predicted population boom in places including Lagos, Nigeria; Jakarta, Indonesia; Dhaka, Bangladesh; and Delhi, India was poised to significantly outpace the ability for governments, NGOs, or the private sector to physically build the structures necessary to shelter them. But a breakthrough in 3D printing in 2035 has significantly reduced costs and the need for raw materials. These 3D printed structures can be made through an intuitive app available on any mobile device. Neighborhoods made from 3D printing are quickly being established across a number of global megacities. The only downside is an emerging concern that 3D Now, the company that owns the intellectual property for the technology, has become a monopoly and could raise prices for 1 billion people who can afford it the least. This issue will be prominent at the U.N. Habitat convening later this year.

Source: http://www.thecoolist.com/transforming-interiors-designs-modular-smart-homes/transformer-apartment-by-vlad-mishin-1/

TRANSFORMER

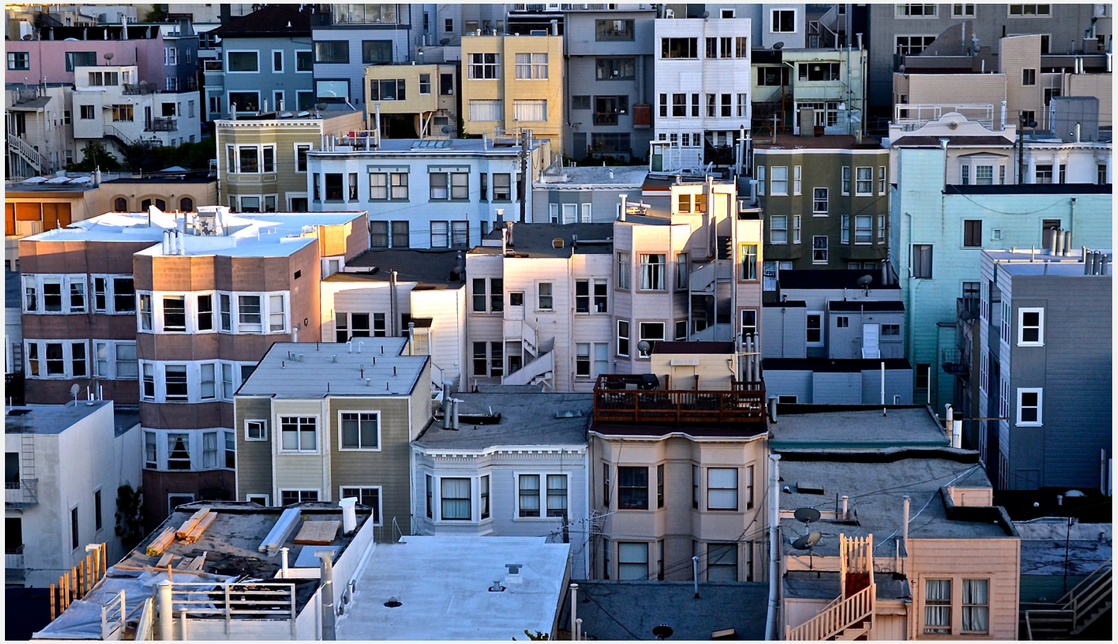
KEY USER LENS:

- **Young and Aspirational**
- **Multigenerational and Multifamily**
- **The New Middle**
- **Elderly and Infirm**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• Transitional window glass • Bio walls that breathe and grow • Furniture that can shape-shift for maximum flexibility • Structures with fold-out walls and cantilevered additional floor space that collapse into the main frame of the home when not needed
POLICY	• Evolution of housing code to allow for adjustable structures

Since the beginning of the 21st Century, cities around the world recognized the growing problem of affordable housing, but repeatedly focused on addressing the symptoms rather than the root cause. For housing to be affordable requires it be considered to be more like a commodity, but for housing to be an asset, as homeowners and aspiring homeowners desire, requires it to be personalized with attractive features. However, in 2035, developers have emerged that are disrupting this problem by achieving both goals at once. From the outside, these new homes look mostly the same, and quite basic. However, the inside offers a multitude of choices and features at prices made affordable by a drop in costs of many advanced materials and digital technologies. Silicone glass exterior skins allow occupants to change the transparency of walls and manage the interior climate of the home. Rooms can easily transform to serve different functions: smart walls change shape using actuators pushing and pulling a flexible skin to create new walls, seats, or shelves; foldaway kitchens can become foldout offices; lofts can cantilever out from walls and ceilings; and large living spaces can sub-divide into several bedrooms. Your home can be whatever you need it to be today, and something entirely different tomorrow.



FUND MY HOME

KEY USER LENS:

- **Refugees and Slum Dwellers**
- **Young and Aspirational**
- **The New Middle**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• Crowdfunding for homes on the blockchain
MARKETS	• Perception shifts for home ownership
POLICY	• Joint title and partial title, shared between multiple parties, facilitate this trend

As homeownership and traditional housing finance became less accessible throughout the 2020s, new platforms began to emerge for crowdfunding homes. This trend began with a focus on real estate investment. The company eFund, founded in 2015, has become a global leader in funding multifamily buildings. But the newest companies among this set now work with individuals who travel frequently, families seeking to share space with childcare providers, and even groups of friends and strangers who would not otherwise be able to afford to own a home. In 2035, homeownership, once thought to be going the way of the dinosaur, is now at an all-time high, not just in North America, but also increasingly across Asia as well, where many of the platforms are accessible even to those who are unbanked. But the most revolutionary change has perhaps been cultural—a new social compact has emerged from the cooperation and collaboration necessary to utilize these crowdsourcing platforms. Anecdotes abound of an increased feeling of community, stronger ties among neighbors, and a recognition that it's actually not difficult for people from different backgrounds and traditions to get along, even within the same house.

FEEL AT HOME NARRATIVE[165]

Housing is much more than the buildings we live in. Where we live and have lived is deeply connected to who we are and who we want to be. This narrative explores ways that new types and features of housing will influence how we might be feeling at home in the future.

Scenarios that comprise this narrative:

- Digital Life
- End of Stuff?
- The New Netflix and Chill

DIGITAL LIFE

KEY USER LENS:

- **Young and Aspirational**
- **The New Middle**
- **Affluent and Savvy**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY	• VR, AR, mixed reality (MR), and Avatar technology with advanced haptics allow people to access any experience they want or need
MARKETS	• Affordable avatars are ubiquitous due to ease-of-use and accessibility through millions of rent centers across the globe
POLICY	• Stringent safety policies in place through AI to allow the monitoring of avatars for public safety

As VR technologies have matured, the old real estate trope, "location, location, location," is becoming an artifact of the past. In 2035, physical locations—both interiors and exteriors—can now be recreated in virtual forms that are nearly indistinguishable from the real thing. Haptics are now standard in most advanced VR experiences, adding a true human sense of touch to virtual experiences. Projection mapping and wearable technologies allow individuals to experience the same room as totally different spaces. New communities have developed in rural and remote locations once considered undesirable. Middle-income families, especially those who seek more living space and more traditional communities, have been able to establish physical roots while maintaining access to people and experiences still found mostly in crowded urban centers. In the U.S., political and social scientists are tracking how these migrations are helping to improve communications, empathy, and the social fabric of the country.

THE END OF STUFF?

KEY USER LENS:

- **Young and Aspirational**
- **The New Middle**
- **Affluent and Savvy**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY | • Replicator or fabricator technology that can create basic household items on demand

Since 2018, despite the periodic popularity of decluttering, one trend had seemed inexorable around the globe: as wealth increases, consumers demand more goods. However, a potentially revolutionary shift has been afoot in recent years as new technologies have emerged that allow people to reduce many household items such as furniture, linens, clothing, and children's toys to digital form in files that fit on the latest chip drives. These items can be recreated quickly and cheaply on demand. An immediate negative impact has been felt by moving companies—instead of hauling their possessions wherever they go, many families are merely recreating the stuff they use every day at their new home, while keeping many items used less frequently (such as winter coats, old school books, and fine china) in electronic form until they are needed. The CEO of digital replication company ReplicateMe (recently acquired by Amazon) announced this month that by the end of the year, his company will add another 1 million items to its catalogue of things that can be reproduced and delivered by drone on demand within an hour in 100 cities around the globe. Many people find that they forget about items saved electronically, and ultimately realize they didn't really need or want them after all. Could this finally be the end of stuff?

THE NEW NETFLIX AND CHILL

(From Floating Knowledge – Arial Daniels)

KEY USER LENS:

- **Young and Aspirational**
- **Elderly and Infirm**
- **Affluent and Savvy**

KEY BREAKTHROUGHS NEEDED

TECHNOLOGY | • Virtual worlds via avatar technology

One of the downsides to spending more time in virtual worlds is loneliness. Indeed, human connectedness seems to be a fundamental need we will not outgrow. Homes in 2035 have acknowledged this by incorporating semi-virtual spaces where family members and friends across different geographical locations can meet and interact. Technologies now can capture select physical features from the living spaces of several people at different geographical locations—walls, entrances, sofas, views, pictures, etc.—and then superimpose them in a common space that all can enter and share. Being at home alone no longer means feeling lonely.

PART IV: CHANGING THE FUTURE OF HOUSING

BREAKTHROUGHS NEEDED

In order to achieve the preferred future state described in Section III, additional breakthroughs are needed in technology, markets, and policy.

- Technology breakthroughs include the development of entirely new technologies, the acceleration of already emerging technologies, or the integration of existing technologies in an entirely new application. At XPRIZE, we give special attention to the convergence of exponential technologies to create leapfrogs within a sector.

- Market breakthroughs include mechanisms for accelerating the commercialization of new products and services, as well as innovative approaches to investment and financing.

- Policy breakthroughs include new policy, regulation, and standards or codes that enable technology and market breakthroughs or incentivize and empower people and communities to adopt new technologies and adapt to change.

We have identified several breakthroughs. Some of these represent incremental, yet essential, change that must happen to achieve the preferred future state. Others represent true moonshots that have the potential to transform housing—and life—as we know it today.

To facilitate a deeper understanding of the relationship between the problems and potential breakthroughs, each snapshot in this report has identified breakthroughs that have been called out. Additionally, each one has been categorized by area of breakthrough: technology, markets, and policy.

WHAT IS AN XPRIZE?

An XPRIZE is a large-scale, monetary award given to the first team to achieve a specific goal, set by XPRIZE, which has the potential to positively impact humanity. XPRIZE competitions are powerful tools for innovation. Rather than awarding money to honor past achievements or directly funding research, an XPRIZE incites innovation by tapping into our competitive and entrepreneurial spirit.

Prizes spur innovation, and are being used across all sectors from philanthropic individuals to governments to corporations to non-profits. They are especially useful tools for solving

problems for which the objective is clear, but the way to achieve it is not. By attracting diverse talent and a range of potential solutions, prizes draw out many possible solutions—many of them unexpected—and steer the effort in directions that established experts might not go, but where the solution may nonetheless lie. This document outlines how XPRIZE partners with organizations to design, launch, operate, and award prizes.

POTENTIAL XPRIZE COMPETITIONS

Through multiple back casting and scenario building exercises, we have picked 16 breakthroughs that we believe offer the most potential for Lowe's and XPRIZE to create massive, global impact.

Each of the following breakthroughs is tied to a specific problem supporting the overall grand challenge for housing as previously identified in this report. Each breakthrough is evaluated based on four criteria: impact potential, level of audacity, market readiness level, and desired timeline for impact.

IMPACT POTENTIAL:

At XPRIZE, we are focused on impacting the lives of real people, so assessing the impact potential of a prize ensures that our efforts are always dedicated to the greatest impact for the benefit of humanity. Prizes given a score of low represent an impact potential of less than 1 billion people. Prizes given a score of medium represent an impact potential of approximately 1-3 billion people. Prizes given a score of high represent an impact potential of approximately 3-5 billion people. And prizes given a score of very high represent an impact potential of approximately 5 billion people or more.

LEVEL OF AUDACITY:

An XPRIZE has to be achievable but also has to be audacious and cutting edge in order to maximize impact. This score represents the general level of technical audacity that teams will have to undertake in order to achieve the prize: medium, high, or extreme.

MARKET READINESS LEVEL:

This score represents a general indication of where the market is today in relation to its readiness to adopt what would be produced by a given prize. A low score illustrates that the market has produced some early stage experimentation in the given field, but not much beyond hypotheses and testing. A score of medium indicates that there has been some investment into the concept but it is still very niche. A score of high indicates that markets are aware of the concept and it has received considerable attention and investment.

DESIRED TIMELINE FOR IMPACT:

At XPRIZE, we look out into the future and we recognize that many of these breakthroughs will happen on their own in the next 10-20 years. But we are looking to hasten these breakthroughs to bring their benefits to humanity sooner. The dates presented in these criteria indicate when we hope to make these breakthroughs a reality.

BREAKTHROUGH 1: WIRELESS ELECTRICITY TRANSMISSION

Imagine an XPRIZE that will allow an entire home to operate free from wires and cables.

Using ultrasound, near-field radio frequency transmission, and other similar technologies, this XPRIZE has the potential to allow homes to operate completely free of conventional wiring; reducing cost, waste, and complexities related to replacing or rewiring a home.

The winning team will wirelessly transmit electricity throughout a small home without using any internal wiring. The home must be able to safely charge devices, appliances, and be able to provide lighting.

Grand Challenge: Technology
Level of Audacity: Extreme
Market-Readiness Level: Medium
Desired Timeline for Impact: By 2025

WHO WILL THIS IMPACT?

This project has the potential to aid all six user groups, but may be of particular interest to the affluent and savvy, as well as the young and aspirational groups. The former is financially equipped to purchase new technology and the latter is likely to be more comfortable using integrated technology than older generations.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

Housing in the future will need to be more sustainable, which means we need to use fewer resources and be less dependent on large-scale infrastructure. Roughly 800 million people across the world do not have access to basic electricity and more than 1 billion have intermittent access to electricity. Eliminating traditional wiring will allow these regions to more easily scale infrastructure.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

Currently, there is little incentive for both governments and big businesses to replace billions of dollars' worth of existing infrastructure or alter their models of construction.

Tech companies that are working on such products are often in competition with each other, which has resulted in a wide array of products that cannot work with one another. What's more, the high prices of new technology along with long device replacement cycles

means consumers do not or cannot buy new items easily.
Innovators need a platform that allows for rapid experimentation of new ideas and technologies.

WHO IS WORKING ON THIS RIGHT NOW?

There are a number of innovative companies working to create smart homes. WiTricity, a U.S.-based company, manufactures devices for wireless energy transfer using resonant energy transfer based on oscillating magnetic fields.[166] Disney Research has developed a new method of wirelessly transmitting power throughout a room, enabling users to charge electronics using near-field standing magnetic waves that fill the interior of a room.[167] However, these technologies are still incapable of transmitting electricity through the physical barriers found in every home, like walls, rafters, and furniture. Additionally this technology lacks the energy efficiency required to make the innovation truly transformational at scale.[168]

BREAKTHROUGH 2: INNOVATIVE COOLING

Imagine an XPRIZE that will permanently replace current air conditioning with highly affordable, planet-saving options.

Nearly 90 percent of American homes have air conditioners, which account for about 6 percent of all of the country's residential energy use.[169] These units release approximately 100 million tons of carbon dioxide each year.[170] This XPRIZE has the potential to eliminate the negative impact of air conditioning worldwide by utilizing alternative cooling technologies that build on innovations like thermoelastic and latent cooling.

The winning team will retrofit an entire community with non-refrigerated cooling systems that significantly reduce emissions of greenhouse gas hydrofluorocarbon (HFC) at an affordable price point.

Grand Challenge: Demographics, Resilience, Environment
Level of Audacity: High, if proven at scale
Market-Readiness Level: High
Desired Timeline for Impact: Urgent, 2019-2023

WHO WILL THIS IMPACT?

This XPRIZE can positively impact all users, as rising global temperatures will make cooling systems not only desirable for wealthier families, but also essential to maintain health and safety for the elderly and infirm as well as for refugees and slum-dwellers.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

The rising middle class and increasing temperatures across the globe are driving up the use of air conditioning units, which creates stress on energy grids and contributes to harmful HFCs in our atmosphere. This XPRIZE can create new innovations to reinvent household level cooling at significant scale, thereby saving our planet and decreasing energy consumption exponentially.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

Currently, there is no incentive for government intervention or for flourishing multibillion-dollar industries like GE to change their products, which are in high demand. Innovators have yet to produce a solution that is considered valuable enough to be commercialized.

Along with technological advances necessary to produce non-refrigerated cooling, the public needs to be made more aware of the negative impact of HFCs in our atmosphere. Because the new middle group can afford existing air conditioning units, and likely already owns them, they will need incentives that encourage them to adopt new technology. This can be achieved through policy intervention and tax benefits for early adopters.

WHO IS WORKING ON THIS RIGHT NOW?

The United States Agency for International Development (USAID) is investigating ways to incorporate passive or evaporative cooling into communities where stress on the power grid is being heavily influenced by air conditioning units.[171] Additionally, some small companies are developing alternative cooling technologies to be implemented in homes off the grid.[172] Universities are also exploring innovative cooling technologies. Stanford University, for example, is currently investigating a high-tech mirror-like optical surface and recently demonstrated how it can be used in the process of radiative sky cooling to passively cool a fluid and, in doing so, connect it with cooling systems to save electricity. Nonetheless, these technologies have yet to scale and solutions are not yet targeted toward the mass market.[173]

[166] "About," Witricity, accessed December 14, 2017, http://witricity.com/company/.
[167] "Wireless Power Transmission Safely Charges Devices Anywhere Within A Room," Disney Research, accessed December 14, 2017, https://www.disneyresearch.com/innovations/wireless-power-room/.
[168] Disney Research, "Wirleless."; Anthony Carboni, "Power Your Entire Home Without Wires," Seeker, March 20, 2014, https://www.seeker.com/power-your-entire-home-without-wires-1792444310.html.; "Japan Space Scientists Make Wireless Energy Breakthrough," Phys.org, March 15, 2015, https://phys.org/news/2015-03-japan-space-scientists-wireless-energy.html.; Fiona Macdonald, "Success! Scientists Have Achieved Wireless Energy Transfer Across 55m," Science Alert, March 13, 2015, https://www.sciencealert.com/scientists-have-transmitted-energy-wirelessly-across-55-metres.
[169] "Residential Energy Consumption Survey," U.S. Energy Information Administration, August 9, 2011, https://www.eia.gov/consumption/residential/reports/2009/air-conditioning.php.
[170] "World Carbon Dioxide Emissions Data by Country: China Speeds Ahead of the Rest," The Guardian, 2016, https://www.theguardian.com/news/datablog/2011/jan/31/world-carbon-dioxide-emissions-country-data-co2.
[171] Mansi Jayswal, "To Examine the Energy Conservation Potential of Passive and Hybrid Downdraught Evaporative Cooling: A Study for Commercial Building Sector in Hot and Dry Climate of Ahmedabad," Energy Procedia 30 (2012): 1131-1142, https://doi.org/10.1016/j.egypro.2012.11.126.
[172] "Types of Cooling Systems," Smarter House, accessed December 14, 2017, http://smarterhouse.org/cooling-systems/types-cooling-systems.; M.S. bin Misaran, C.M. Chu, S. Kumaresen, M. Mashud, M.M.Rahman, and M. Sarker, "A Passive Cooling System of Residential and Commercial Buildings in Summer or Hot Season," IOP Conference Series: Materials Science and Engineering, accessed December 14, 2017, http://iopscience.iop.org/article/10.1088/1757-899X/100/1/012031/pdf
[173] Bin Misaran, "A Passive."; Smarter House "Types."; Taylor Kubota, "Cooling System Works Without Electricity," Science Daily, September 5, 2017, https://www.sciencedaily.com/releases/2017/09/170905145530.htm; Omar Abdelaziz and Van Baxter, "Current and Future Air-Conditioning (AC) Technologies," Oak Ridge National Laboratory, 2016, https://www.iea.org/media/workshops/2016/egrdspacecooling/7.VanD.Baxter.pdf.

BREAKTHROUGH 3: NEW SELF-HEALING CONCRETE

Imagine an XPRIZE that will create a permanent solution to cracked concrete that is putting physical infrastructure, like buildings and bridges, at risk.

This XPRIZE has the potential to address the growing issue of aging infrastructure around the world and act as an overall retrofitting solution. At the same time, this XPRIZE could reduce the negative effects of producing traditional concrete, including erosion and waste.

The winning team will create an easily deployable solution that will allow cracks in existing concrete to repair itself, both quickly and affordably.

Grand Challenge: Technology, Resilience
Level of Audacity: High
Market-Readiness Level: High
Desired Timeline for Impact: Urgent, 2020

WHO WILL THIS IMPACT?

This will benefit the new middle and multi-family and multigenerational groups who may be living in older buildings that have degraded over time. Self-healing concrete that could be integrated into existing structures would allow them to stay in their homes, which may be older and more run-down. It could also help refugees and slum-dwellers who are in need of safe structures as well as the affluent and savvy groups, who may be interested in building additional homes with self-healing concrete.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

Current costs to fix and maintain old concrete infrastructure runs into trillions of dollars. Until this is solved, crumbling infrastructure will add to the housing deficit. Self-healing concrete will also reduce waste and pollution related to building new structures when old ones fall apart. This XPRIZE will have the ability to fix both public and private infrastructure on a large scale.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

Governments are highly motivated to find a solution to crumbling structures, but they are risk averse to non-traditional solutions. To develop these solutions, we need a platform that safely allows for rapid experimentation of new ideas and technologies.

New technology is not easily integrated into existing infrastructure. Concrete is extremely alkaline. The "healing" bacteria that has been developed thus far to repair concrete must wait dormant for years before being activated by water. There is a need to find bacteria or other mediums that can survive the harsh environment of concrete and, at the same time, produce the necessary reparative qualities.

WHO IS WORKING ON THIS RIGHT NOW?

Only one or two experiments regarding self-healing concrete are currently in the works and are mostly affiliated with universities. The primary research and development for this product has been developed by Hendrik Jonkers of Delft University in The Netherlands.[174] However, nothing has been completed and brought to market at scale, and no one is working on a product that could impact existing concrete infrastructure.

BREAKTHROUGH 4: MODULAR MEGASTRUCTURE

Imagine an XPRIZE that will allow a 100-floor building to be built in 30 days.

The world's population is projected to increase from 7.4 billion in 2017 to 8.6 billion in 2030 and 9.8 billion in 2050. As the demand for housing around the world grows at unprecedented rates and land continues to become more expensive, this XPRIZE has the potential to develop affordable, resilient housing at a massive scale.

The winning team will create a plan to modularize the majority of the building components and assemble them within a short period of time at a reasonable price point.

Grand Challenge: Demographics, Affordability, Adaptability, Environment
Level of Audacity: Very High
Market-Readiness Level: Medium High
Desired Timeline for Impact: 2025-2030

WHO WILL THIS IMPACT?

Housing is neither rapidly built nor is it often affordable for most of the planet. Housing that can be built for less money will likely cost less to rent or own, and will benefit primarily the new middle, multifamily and multigenerational, as well as the elderly and infirm groups.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

As the world's population is projected to increase, half of the world's population growth will be concentrated in just nine countries (in

[174] " "Hendrik Marius Jonkers (The Netherlands): Finalist for the European Inventor Award 2015," European Patent Office, November 20, 2015, http://www.epo.org/learning-events/european-inventor/finalists/2015/jonkers.html.; Vinayak Rathod, "Self Healing Concrete," Slideshare, August 29, 2015, https://www.slideshare.net/VinayakRathod/self-healing-concrete-52205486.; Andrew Stewart, "The 'Living Concrete' That can Heal Itself," CNN, March 7, 2016, http://www.cnn.com/2015/05/14/tech/bioconcrete-delft-jonkers/index.html.

descending order of growth): India, Nigeria, Democratic Republic of the Congo, Pakistan, Ethiopia, the United Republic of Tanzania, the United States, Uganda, and Indonesia.

The severe housing deficit will continue to rise. Today, 330 million families need to find a housing solution. That deficit is expected to increase to 440 million families in 2025.[175] This XPRIZE will allow infrastructure to keep up with the high demands of the growing population.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

Although urbanization is driving investments in infrastructure development, most work is still performed manually and on site, which is costly and time consuming.

Innovation at this scale is risky and as a result, unimaginative and slow. The construction industry is inherently long term. A small error in construction can cause significant harm to humans and the environment. The consequences of construction errors can reverberate for decades, centuries, and even a millennium.

Excessive regulation of the industry and its supply chain can hinder innovation and, currently, rapid building is focused on markets where safety regulations are flexible. Innovators need a platform that allows them to integrate existing and new modular constructing technologies safely and quickly.

WHO IS WORKING ON THIS RIGHT NOW?

There are many innovative architecture firms and university departments designing and considering these kinds of self-contained megastructures, but few that are considering how these structures could be built rapidly. Broad Sustainable Building, a prefab construction firm based in China, is one of the few. They erected a 57-story skyscraper in just 19 days using their innovative Core Tech: Core Tubular Stainless Steel Slab technology. However, prior to starting construction the firm spent four and a half months fabricating the building's 2,736 core modules off-site. The company is also currently awaiting approval for its 220-floor building, called Sky City. This innovation and accomplishment still lack audacious speed. Increasing the speed and scale at which these processes are possible is where the real moonshot and transformation lies.[176]

BREAKTHROUGH 5: CONSTRUCTION WASTE TO 3D-PRINTED HOME

Imagine an XPRIZE that will allow an entire home to be 3D-printed using construction waste.

Construction waste is the largest driver of solid waste globally. About 40-50 percent of the content of landfills is made up from unused or disposed building materials, including waste from demolished homes.[177] In the U.S., more than 70 percent of municipal waste is from construction and building materials.[178]

Using discarded construction waste as its primary materials base, new 3D printing technologies developed by this XPRIZE have the ability to not only reduce construction waste and raw materials extraction, but also address the rapidly growing demand for housing at scale.

The winning team will 3D-print the foundation and walls for a 1,000-square foot home with 90 percent of the materials recycled from existing construction waste.

Grand Challenge: Affordability, Technology, Resilience, Environment
Level of Audacity: Extreme
Market-Readiness Level: High
Desired Timeline for Impact: 2025

WHO WILL THIS IMPACT?

Housing is not affordable for much of the planet. Creating homes without needing to use costly raw materials could help the new middle along with refugee and slum-dwellers. Cutting down on waste will have ecological benefits for all groups, particularly those who live in cities.

This XPRIZE could also appeal to the young and aspirational group, who may not have as many qualms about repurposing waste.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

Construction of a typical single-family home generates a waste stream of three to seven tons—including wood, drywall, and roofing materials that are sent to the dump. Around the globe, more than 40 percent of all raw materials are consumed in the construction process. In addition to wasting valuable resources, construction contributes significantly to environmentally harmful emissions.

This XPRIZE not only eliminates the need for raw materials, but also allows communities to create a closed loop system, in which their waste becomes their building materials.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

There is no incentive for government or existing industries to innovate in this area, and what's more, the stigma surrounding the use of garbage as raw materials may cause industries to fear that such investments would not be profitable.

We need to adjust social norms so that people are willing and, in fact, desire a home made out of recycled waste materials. The waste

[175] Jan Mischke, "Addressing the Global Affordable Housing Challenge," McKinsey Global Institute, May 2016, http://pubdocs.worldbank.org/en/773591464879251915/housing-finance-conference2016-session-1-presentations.pdf.
[176] ProductShow-76.aspx.; "Chinese Construction Firm Erects 57-Storey Skyscraper in 19 Days," The Guardian, April 30, 2015, https://www.theguardian.com/world/2015/apr/30/chinese-construction-firm-erects-57-storey-skyscraper-in-19-days; "Megastructures and the Future of Architecture," IDI, July 15, 2014, https://idesigni.co.uk/blog/megastructures-and-future-architecture/.; Eoghan Macguire, "The Chinese Firm That can Build a Skyscraper in a Matter of Weeks," CNN, July 26, 2015, http://www.cnn.com/2015/06/26/asia/china-skyscraper-prefabricated/index.html.; David Xu, "How to Build a Skyscraper in Two Weeks," McKinsey and Company, May 2014, https:// www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/how-to-build-a-skyscraper-in-two-weeks.
[177] Wills, "The Lowdown."
[178] "Advancing Sustainable Materials Management: 2014 Fact Sheet," United Stated Environmental Protection Agency, November, 2016, https://www.epa.gov/sites/production/files/2016-11/documents/2014_smmfactsheet_508.pdf.

management industry needs to engage positively with the designers and manufacturers of 3D printing devices. They need simple, cost effective, scalable techniques that can be developed to segment and process construction waste and turn it into safe 3D printer filament.

WHO IS WORKING ON THIS RIGHT NOW?

Refil, part of The Netherland's design agency Better Future Factory, produces 3D printing filament made from recycled plastics.[179] Winsun New Materials, a startup based in Suzhou, China, has recently begun producing 3D-printed residential dwellings that use a mix of concrete and recycled glass fiber material. However, there is nothing being done to turn construction waste materials into 3D printer filament.[180]

BREAKTHROUGH 6: THE CARING CONNECTED HOME

Imagine an XPRIZE that will create an intelligent home system that monitors residents' safety, health, and comfort.

Currently, there are many different manufacturers, networks, standards, and devices being used to connect the smart home. Because these companies and products aren't incentivized to share their technology, many devices cannot work together. This XPRIZE has the potential to solve these interoperability issues and provide an integrated, transformational smart solution to homeowners.

The winning team will create an autonomous, intelligent, and integrated home system that simultaneously monitors the personal health, comfort, and safety of four of its residents.

Grand Challenge: Technology, Adaptability
Level of Audacity: High
Market-Readiness Level: High
Desired Timeline for Impact: 2025

WHO WILL THIS IMPACT?

The affluent and savvy as well as the young and aspirational will likely be attracted to this innovation as they either have the money to afford technology or are most comfortable using it. Smart homes could also benefit the elderly and infirm by providing them with AI and robotic assistance.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

Smart homes have the potential to not only improve the function of a home but also the lives of those who reside in them. A caring home could support residents' health, reminding them to drink more water or make a doctor's appointment.

Interoperability challenges keep smart home technology from providing benefits that are truly transformational, like increasing their levels of convenience, and bringing holistic home solutions capable of improving health and safety.

Why does this white space exist and what catalyst is needed to change this?

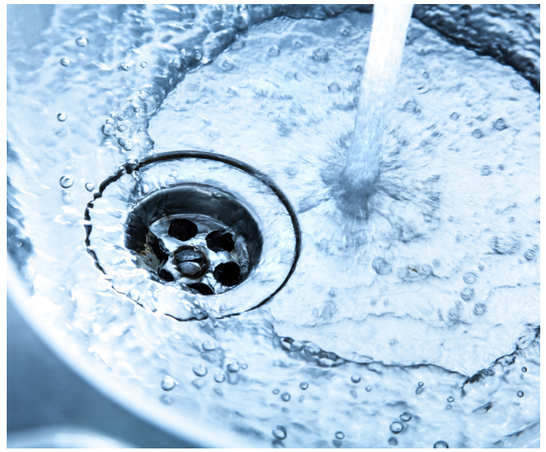
Currently, the biggest obstacle facing smart home technology is integration. There are a number of organizations and companies working to develop smart home solutions, but fragmentation in the industry and confusion among consumers as to which devices provide the most value, and which will be the most promising for the future, are hindering transformative integrated solutions.

To facilitate sharing, we need policies that mandate that data is owned solely by the person who produces it. Companies must align on the need to collaborate to provide a common protocol that will allow these devices to communicate with each other

WHO IS WORKING ON THIS RIGHT NOW?

The primary innovation is focused on security products, sensor technologies, smarter robotic appliances (including AI), and cyber security. Little attention is given to integrating systems or fighting for data sharing across devices.[181]

BREAKTHROUGH 7: ZERO WASTEWATER FOR THE HOME



Imagine an XPRIZE that will allow a household to use and reuse its water endlessly.

Water scarcity affects more than 30 percent of the global population. An estimated 833 million people do not have access to clean water.[182] By using innovative methods of water purification and recycling, this XPRIZE has the potential to bring a renewable solution to these under-resourced populations.

The winning team will create a home water collection, purification, and monitoring system that will allow for an endless loop of reusing waste. Each system must meet World Health Organization (WHO) standards for potable water and have an accurate alert system for possible contamination. The system should cost no more than a traditional reverse osmosis

[179] "Refil," Re-filament, accessed December 15, 2017. http://www.re-filament.com/.
[180] "New Home? Just Press Print…Introducing the 3D Printed House," Fibonacci Stone, accessed December 15, 2017, http://www.fibonaccistone.com.au/3d-printed-house/.
[181] Diana Olick, "Why 2017 Will Finally Be the Year of the Smart Home: Consumers Figure it Out," CNBC, January 4, 2017, https://www.cnbc.com/2017/01/04/why-2017-will-finally-be-the-year-of-the-smart-home-consumers-figure-it-out.html.; Lyman Chapin, Scott Eldridge, and Karen Rose, "The Internet of Things: An Overview," Internet Society, October 2015, https://www.internetsociety.org/wp-content/uploads/2017/08/ISOC-IoT-Overview-20151221-en.pdf.; Nick Hastreiter, "What's the Future of Smart Home Technology?" Future of Everything, April 2017, http://www.futureofeverything.io/2017/04/12/future-smart-home-technology/.
[182] "The Water Crisis," Water.org, accessed December 15, 2017. https://water.org/our-impact/water-crisis/.

home purification system, approximately $150.

Grand Challenge: Technology, Resilience
Level of Audacity: High
Market-Readiness Level: Low-Medium
Desired Timeline for Impact: 2022.

WHO WILL THIS IMPACT?

This XPRIZE has the potential to help all six user groups, but especially refugees and slum-dwellers that have limited access to clean water.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

By using innovative methods of water purification and grey-water recycling, this XPRIZE has the potential to bring a renewable solution to households around the world and permanently put an end to the fresh water crisis.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

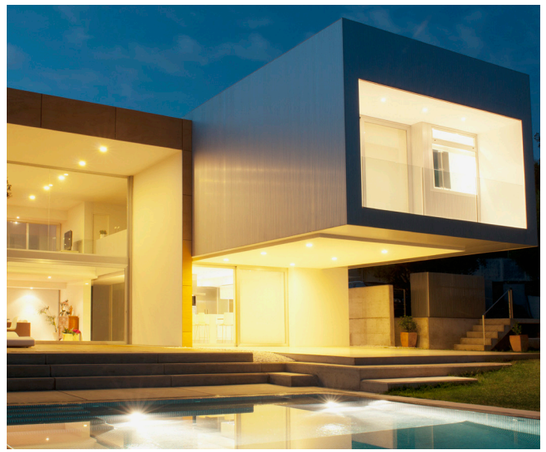
Current technology is constrained by high intensive energy consumption. Additionally, the technology is too expensive to build and integrate at the individual home level.

Along with experimenting to find cost and energy-cutting measures, we need a public relations campaign that raises awareness about the importance of conserving water and allays the fears and distaste many have with the idea of wastewater being purified and reused.

WHO IS WORKING ON THIS RIGHT NOW?

Due to high costs, wastewater reuse systems are only considered at the industrial or city level rather than for individual homes. Zero liquid discharge (ZLD), a wastewater management strategy that eliminates liquid waste and maximizes water usage efficiency, has attracted renewed interest worldwide in recent years. Nonetheless, this technology is still only being considered on an industrial level, rather than integrated as a homeowner solution.[183]

BREAKTHROUGH 8: FLEXIBLE HOME



Imagine an XPRIZE that will adapt to a family's changing needs.

Compared to 2017, the number of persons globally aged 60 or above is expected to more than double from 2017 to 2050, rising from 962 million people to 2.1 billion people. This XPRIZE has the potential to mitigate the costs surrounding public health care systems, pensions, and social protections, as well as improve the quality of life for millions of aging individuals.

The winning team will create an automated home healthcare system that allows a person to age in place. The system must be able to address all five areas of eldercare: accurately provide medication, assist in self-hygiene, call for help when needed, meet nutritional needs, and provide companionship.

Grand Challenge: Demographics, Technology, Adaptability
Level of Audacity: Very High
Market-Readiness Level: Very High
Desired Timeline for Impact: 2022

WHO WILL THIS IMPACT?

The elderly and infirm along with multi-family and multigenerational groups will benefit from advancements in AI, robotics, and sensing technologies that allow aging family members to remain in their homes longer.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

The majority of the elderly population wish to stay at home as they age (nearly 90 percent of seniors desire to stay in their homes as long as possible); however, the design of their homes and communities does not suit older adults who lack the mobility, agility, and swiftness of the young. This XPRIZE would allow the elderly to live out their golden years in their preferred homes.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

Most companies are largely focused on a single area, such as security, and the industry lacks integrated, whole-home solutions. Current technology also does not incorporate both AI and the IOT and how they relate to a home's need for structural change. We need technology that allows housing to adapt to those living inside it, rather than forcing the inhabitants themselves to adapt.

We also need to address the public's aversion to AI and robotics both regarding its ability to care for the elderly and infirm and the fear that eliminating human caregiving will deprive this group of its already limited social interactions.

WHO IS WORKING ON THIS RIGHT NOW?

Some small innovative organizations are attempting to address the changing housing needs of individuals over time. The CityHome, developed by Kent Larson's Changing Places Research Group at MIT, has developed an ultra-efficient, responsive urban micro-unit apartment, providing a hardware and software ecosystem for personal space customization. Senior care companies like Lively, a connected

[183] Sumana Narayanan and Bharat Lal Seth, "Toward Zero Discharge," Down to Earth, May 31, 2011, http://www.downtoearth.org.in/coverage/towards-zero-discharge-33489.; Willy Verstraete, "ZeroWasteWater: Short-Cycling of Wastewater Resources for Sustainable Cities of the Future," International Journal of Sustainable Development and World Ecology 18, no. 3 (2011): 253-264, http://www.tandfonline.com/doi/abs/10.1080/13504509.2011.570804.; Martin Smith, "Perspectives on Net Zero—What Does the Future Look Like?" Verdical Group, September 9, 2016, http://verdicalgroup.com/perspectives-on-net-zero-what-does-the-future-look-like/.; "Net Zero 2016," Verdical Group, August 19, 2016, http://verdicalgroup.com/net-zero-2016/.; Menachem Elimelech and Tiezheng Tong, "The Global Rise of Zero Liquid Discharge for Wastewater Management: Drivers, Technologies, and Future Directions," Environ. Sci. Technol. 50, no. 13 (June 2016): 6846–6855, https://www.ncbi.nlm.nih.gov/pubmed/27275867.

[184] "Remodelers for Aging in Place," In Your Home, accessed December 15, 2017, http://www.iyhusa.com/AginginPlaceFacts-Data.htm.

home health platform, provides a series of sensors that, when placed in an elderly person's home, tracks and reports daily activities.[185]

BREAKTHROUGH 9: BLOCKCHAIN FOR REAL ESTATE

Imagine an XPRIZE that will allow an entire city to transfer all real estate titles to the blockchain within 10 days.

Rising rents and a lack of affordable housing are making it impossible for a growing number of people to settle in cities across the globe. Housing prices have surged since the 1970s due to rising costs of land, increased regulation, and foreign investors snatching up available properties. This XPRIZE could address the need for openness and transparency and develop fewer intermediaries who increase the costs and time to purchase land or a home.

The winning team will create a system to verify and upload existing real estate records to the blockchain accurately and within a brief period of time.

Grand Challenge: Affordability, Technology
Level of Audacity: High
Market-Readiness Level: High
Desired Timeline for Impact: 2020

WHO WILL THIS IMPACT?

Speeding up the system, providing more transparency, and offering safer investments will benefit all people in need of housing and land titling. This XPRIZE will especially impact the new middle, who are being priced out of home buying options, and refugees and slum-dwellers, who are in desperate need of affordable housing.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

This technology could make buying or selling a house, applying for a mortgage or taking out a property loan a safe, streamlined, and transparent process.

This XPRIZE has the potential to transform the way we buy and sell homes by eliminating the hidden costs and inefficiencies of the housing market at scale as well as providing a new method of land title and ownership in countries where land tenure is uncertain or corrupt.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

Concern about systemic corruption and insecure database management is a major hurdle to adopting blockchain technology. Most buyers and sellers make use of escrow and title companies for third-party verification—a safety net to make sure both parties keep their end of the deal, as well as to reduce the risk of fraud. The real estate market does not have an incentive to adopt this model as it could reduce opportunities to capitalize on inefficiencies of the home and land purchasing process and tenure. Government bodies also slow down the system by placing additional restrictions or costs on the sale or transfer of real estate.

In order to usher in the adoption of blockchain technology, we need policy mandates and incentives at the city and state level.

WHO IS WORKING ON THIS RIGHT NOW?

In July 2016, Sweden became the first Western country to explore the use of blockchain technology for real estate. The Swedish Land Registry partnered with blockchain startup ChromaWay to test how parties in a real estate transaction—the buyer, seller, lender, government—could track a deal's progress on a blockchain.

Other countries at the forefront of using blockchain for real estate include The Republic of Georgia, Honduras, and Brazil, which announced a pilot program earlier this month. There have also been a number of one-off experiments but limited investigation as to how entire cities our communities could be transferred to the blockchain at scale.[186]

BREAKTHROUGH 10: COMMUNITIES FOR THE DISPLACED

Imagine an XPRIZE that will fix the refugee housing crisis.

The world is facing its largest refugee crisis since World War II. As families flee their homes in the face of violence, persecution, or natural disasters, the need to not only shelter, but to create homes for displaced people continues to rise. This XPRIZE has the potential to provide integrated, flexible, and culturally relevant housing for the 65 million refugees and displaced persons around the world today.

The winning team will incentivize groups from around the world to design, prototype, manufacture, and implement at scale the next generation of housing for displaced people that is integrated, flexible, and culturally relevant—houses that can be homes.

[185] Clifford Cancelosi, "The Next Generation of Senior Care Technology," A Place for Mom, February 3, 2014, https://www.aplaceformom.com/blog/1-3-14-innovative-senior-technology-startups/.
[186] Danika Wright, "How the Blockchain Will Transform Housing Markets," Phys.org, April 13, 2017, https://phys.org/news/2017-04-blockchain-housing.html#jCp.; Don Oparah, "3 Ways That The Blockchain Will Change The Real Estate Market," TechCrunch, February 6, 2016, https://techcrunch.com/2016/02/06/3-ways-that-blockchain-will-change-the-real-estate-market/.; "Blockchain: The Next Game Changer in Real Estate?" Deloitte, March 3, 2016, https://www2.deloitte.com/nl/nl/pages/real-estate/articles/blockchain-the-next-game-changer-in-real-estate.html.

Grand Challenge: Demographics, Adaptability, Environment
Level of Audacity: High
Market-Readiness Level: High
Desired Timeline for Impact: Urgent, 2020

WHO WILL THIS IMPACT?

Refugees and slum-dwellers are in desperate need of better housing.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

Existing refugee housing solutions represent a one-size-fits-all model and have not, in large part, been implemented at scale. The tent-like structures commonly used by organizations like the UNHCR offer a quick solution for displaced people but offer little protection from the natural elements, much less provide a comfortable or inviting home.

This XPRIZE has the potential to not only provide safe and healthy housing for the growing refugee population, but also to create homes that restore dignity to a marginalized group.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

Refugee housing solutions are still viewed as temporary, when, in fact, refugee populations have persisted in camps for years. The average refugee lives in a camp for roughly 10 years.[187] Because refugee camps are considered temporary solutions, they are not designed to work as the long-term homes they often become.

We need policy changes that press for more permanent housing solutions for refugees along with technological advances that better facilitate off grid living.

WHO IS WORKING ON THIS RIGHT NOW?

Currently, the top three shelters are the Ikea Better Shelter, the Exo Emergency Shelter, and the Humanihut Shelter System, previously discussed in this report. The three designs, particularly the Humanihut Shelter System, offer a vast improvement over the standard UNHCR tent and shipping container homes used in some camps. While the Humanihut could provide the majority of essential needs for displaced persons in emergency situations, these facilities may be insufficient for long-term living, particularly with respect to environmental, community, and cultural relevance.[188]

BREAKTHROUGH 11: PROSTRUCTION

Imagine an XPRIZE that will allow you to grow your home.

Prostruction is a building technique that works to create a symbiotic relationship between bodies and the buildings they live in.

The winning team will prototype a demonstration of synthetic bioengineered materials for the construction industry, which merge together the domains of the physical, digital, and biological. It will enable the construction industry to shift toward processes that are healthy for both the planet and us.

Grand Challenge: Technology, Resilience
Level of Audacity: Extreme
Market-Readiness Level: Low
Desired Timeline for Impact: 2030

WHO WILL THIS IMPACT?

Initially, this XPRIZE will likely appeal to the affluent and savvy group. However, there is a large opportunity to integrate such solutions into the retrofit market. Once integrated into this market, it will trickle both up and down to the affluent market that demands new trends, and also to the refugee and slum-dweller housing market that can take advantage of these technologies when they become more affordable.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

Building on advancements in synthetic biology, computational design, bio-printing, and materials engineering, our bodies and the buildings we inhabit have the potential to be in a symbiotic relationship. By successfully facilitating the fusing together of the physical, the digital, and the biological, this XPRIZE could catalyze the development of homes that are truly net positive, both for our bodies as well as for our environment.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

The building industry is risk averse and learning new building methods takes considerable time and money.

Both radical innovation and new investments are needed in this space. Additionally, a space to incubate and display the benefits of these synthetic biology technologies to not only normalize their appearance to the public but also to make governments aware of their benefits and use so that they change policy, will benefit its adoption.

WHO IS WORKING ON THIS RIGHT NOW?

Terreform ONE, a nonprofit organization for philanthropic architecture and urban ecological design, has run a number of experiments with dendritic microstructures commonly found in mushrooms to direct the growth of structures. Many organizations are investigating the use of mycelium bricks and other natural materials to build structures, but nothing is happening at scale or being integrated into the

[187] Xavier Devictor and Quy-Toan Do, "How Many Years do Refugees Stay in Exile?" The World Bank, September 15, 2016, http://blogs.worldbank.org/dev4peace/how-many-years-do-refugees-stay-exile.
[188] Adam Nowek, "Reacting To Disaster: The Reaction Housing System," Pop Up City, October 12, 2012, http://popupcity.net/reacting-to-disaster-the-reaction-housing-system/.; Emma Chow, "DIY Architecture: First WikiHouses Built," Pop Up City, September 18, 2012, http://popupcity.net/diy-architecture-first-wikihouses-built/.

construction industry. Synthetic biology labs at MIT, Harvard, and Stanford are all working on developing similar materials but the adoption of these materials by the construction industry will continue to be an issue.[189]

BREAKTHROUGH 12: THE FLOATING CITY RETROFIT

Imagine an XPRIZE that will design a self-contained floating city to house 100,000 people.

Sea levels are expected to rise in the coming years, which can have a devastating impact on coastal communities. Millions of people live in areas that are vulnerable to flooding and many could be forced to leave their homes entirely.

The winning team will create and test the complete design for a self-contained floating city that can house, feed, and provide energy for its residents.

Grand Challenge: Demographics, Affordability, Technology, Resilience
Level of Audacity: High
Market-Readiness Level: Low-Medium
Desired Timeline for Impact: 2030

WHO WILL THIS IMPACT?

This XPRIZE will impact all groups because everyone will be affected by climate change. Those living in or around coastal areas are vulnerable to becoming climate refugees and would benefit from floating structures.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

Recent research has predicted that oceans could rise by close to two meters by 2100. Climate change is causing mega-storms and floods to occur every few years, rather than every 100 years. This XPRIZE has the potential to both cope with the negative effects of rising sea levels and, in some ways, even increase the supply of affordable housing stock by building resiliency into existing structures.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

Most disaster-related interventions come after an event. The retrofit market for building resiliency within homes needs revolutionary techniques that will allow them to lift foundations automatically or secure lower levels against flooding due to rising water levels in low-lying areas.

We need to focus on prevention rather than mitigation and policy changes that create new construction codes for areas that are going to be most affected by sea level rise.

WHO IS WORKING ON THIS RIGHT NOW?

A large number of innovative architecture and design firms have been investigating the notion of floating cities in recent years. The Seasteading Institute, a nonprofit based in San Francisco, works to create floating communities. Blue Frontiers, a global organization, is working to create floating islands. The French Polynesian government is interested in these companies' plans and hopes, together, they can expand the utility of the seas by building the world's first floating village under a special governing framework.

Cities that are currently in danger of being flooded by rising sea levels could be saved by innovative technologies that may allow existing structures to float. However, currently, little work in being done in the retrofit and preventions space. Chinese construction firm CCCC commissioned AT Design Office to create an attractive floating city solution that took the form of a sprawling buoyant landmass made from prefabricated hexagonal modules. The self-sufficient island is designed to be zero-carbon, energy efficient, and would include vertical farms and fish hatcheries to produce its own food.[190]

BREAKTHROUGH 13: OFF GRID LIVING

Imagine an XPRIZE that will create a home storage solution for energy.

More than 1 billion people around the world still live without electricity. This XPRIZE has the potential to bring electricity to these underserved populations.
The winning team will decrease costs and radically increase the capacity of technology to capture, store, and distribute solar energy at a grand scale.

Grand Challenge: Technology, Adaptability Resilience
Level of Audacity: High
Market-Readiness Level: Medium
Desired Timeline for Impact: Urgent, 2022

WHO WILL THIS IMPACT?

This will greatly impact refugees and slum-dwellers who either have intermittent or zero access to electricity.

[189] "Imminent Commons: Urban Questions for the Near Future," Tereform, accessed December 16, 2017, http://www.terreform.org/index.html.; "Home," Wyss Institute, " accessed December 16, 2017, https://wyss.harvard.edu
[190] Calum Lindsay, "The Seasteading Institute's Floating Cities Are Designed for Unregulated Innovation," Dezeen,July 27, 2017, https://www.dezeen.com/2017/07/24/seasteading-institute-floating-cities-designed-for-unregulated-innovation-architecture-mini-living-initiative/.; "Floating Architecture," Dezeen, accessed December 16, 2017,https://www.dezeen.com/tag/floating-architecture/.; "About," The Seasteading Institute, accessed December 16, 2017, https://www.seasteading.org/.; "Welcome to Blue Frontiers," Blue Frontiers, accessed December 16, 2017, https://www.blue-frontiers.com/.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

In sub-Saharan Africa, the number of people living without electricity continues to increase, as the population grows faster than advances in electrical access. Many of these people live in rural areas where the costs associated with building traditional electricity infrastructure are considered too high. By creating home storage solutions, this XPRIZE will not only bring electricity to those without, but also decrease our reliance on municipal electric grids.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

Current technology is very expensive for the average consumer. Markets that sell and distribute excess energy are in their early stages.

In order to push the industry forward, we need cheaper technology and incentives for the general population to invest in energy storage and allow them to see the possible revenue stream from the storage and sale of excess energy.

WHO IS WORKING ON THIS RIGHT NOW?

There is a global search for new energy storage technology and some have the potential to open the door to exciting developments. Public utilities and national governments are investing in order to stay relevant and profitable, in addition to tech companies and NGOs in developing countries. However, these power storage solutions still cost thousands of dollars and novel ways of sharing and distributing excess energy are not being investigated. Germany is investing heavily into domestic storage solutions for solar technology. In California, where the state's public utilities commissions have imposed massive energy storage mandates, the market for peak-shifting and storing production is gaining the interest of consumers. Three promising technologies are emerging as potential long-term solutions to energy storage: chemical energy storage, compressed air energy storage, and pumped hydro.[191]

BREAKTHROUGH 14: ALTERNATIVE PAYMENT MODELS

Imagine an XPRIZE that will allow the creation and safe testing of new global financial models that will enable millions of middle-class citizens to house their families affordably.

This XPRIZE has the potential to transform the way we buy and sell homes by eliminating the hidden costs and inefficiencies of the housing market at scale.

The winning team will create a market simulation to test economic and financial models on a global scale.

Grand Challenge: Affordability, Technology
Level of Audacity: High
Market-Readiness Level: High
Desired Timeline for Impact: 2030

WHO WILL THIS IMPACT?

This XPRIZE will impact all user groups but could especially benefit the new middle, along with multi-family and multigenerational groups who are being priced out of housing.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

Housing finance mechanisms are archaic and limited to renting or owning. They are also tied to traditional economic systems of wealth creation that sharply reduce affordability. The need for housing and housing as an asset to wealth creation are increasingly at odds with each other. This XPRIZE will create and test new economic models at scale within virtual worlds to enable breakthrough innovations that allow greater access to housing for millions of people around the world.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

This white space exists because of the increasingly stark imbalance between housing as a basic human need and housing as an asset to be bought and sold. Governments have not incentivized any other system and have little incentive to do so themselves. Traditional models are extremely profitable for the wealthy few.

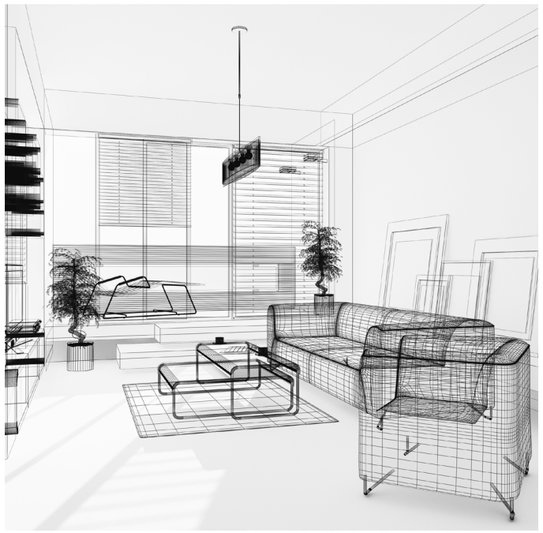
The barriers that need to be overcome here are policy related—not technology related—and contingent upon changing social norms. The perception of personal assets and wealth need to shift in order for something like this to occur.

WHO IS WORKING ON THIS RIGHT NOW?

While the use of simulations is commonly used in the financial sector and economic domain, little attention is awarded to the creation and simulation of essentially different economic and financial models—ones that steer away from contemporary capitalist systems. Enterprise Community Partners, a Maryland-based nonprofit, has been doing work in this area, but not in a scalable manner and their work is dependent on philanthropy.

[191] Giles Parkinson, "The Long-Term Energy Storage Challenge: Batteries Not Included," Greentech Media, December 17, 2013, https://www.greentechmedia.com/articles/read/the-long-term-storage-challenge-batteries-not-included#gs.eYSHfJ8.; Ashley Lovell, "Scientific Breakthrough Reveals Unprecedented Alternative to Battery Power Storage," University of Surrey, December 5, 2016, https://www.surrey.ac.uk/mediacentre/press/2016/scientific-breakthrough-reveals-unprecedented-alternative-battery-power.; Danielle Muoio, "10 Home Batteries That Rival Tesla's Powerwall 2," Business Insider, May 18, 2017, http://www.businessinsider.com/rechargeable-battery-options-compete-tesla-2017-5/#5-sonnen-a-german-company-sells-several-at-home-battery-options-with-up-to-16-kwh-of-storage-the-eco-compact-version-pictured-here-holds-4-kwh-of-energy-and-costs-5950-it-comes-with-the-inverter-included-11.

BREAKTHROUGH 15: DIGITIZATION OF HOME



Imagine an XPRIZE that can turn anything you own into pure information so that it can be recreated anywhere.

In the U.S., the average home contains 300,000 items.[192] Americans accumulation of goods has outpaced the size of their homes. The U.S. has roughly 50,000 storage facilities, with about 7 square feet of storage space for every single American.[193] What if all of this space used to hold goods was suddenly available for other use?

Imagine we could download what we have into a USB drive and take it with us to our new home. This XPRIZE would suggest ways to turn our belongings to digital data, which could then be recreated with 3D printers.

Grand Challenge: Demographics, Affordability, Technology
Level of Audacity: High.
Market-Readiness Level: Low.
Desired Timeline for Impact: 2022.

WHO WILL THIS IMPACT?

This will largely impact the affluent and savvy along with the young and aspirational groups who may be more comfortable integrating new technology into their lives. This could also be helpful for refugees, who may have to leave their belongings at a moment's notice.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

The stuff we own helps shape our identity. Rather than moving our stuff around, capturing these things digitally so that they can be recreated using 3D printing, digital projection, or adaptable materials would enable people to move, either voluntarily or involuntarily, without losing their sense of identity—or their stuff.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

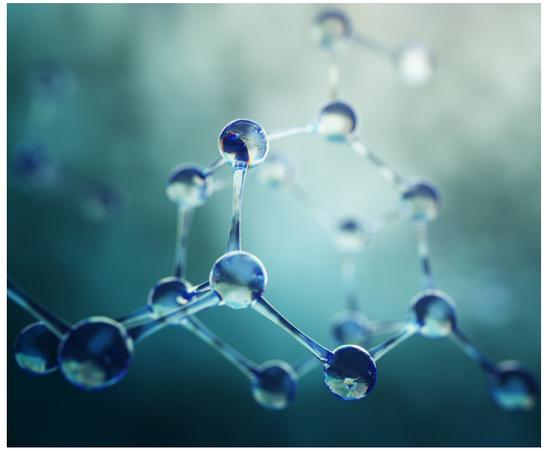
While there are many initiatives to digitize almost every aspect of life, these efforts are siloed and focus on specific area that are easier to digitize. Blockchain technology is currently concentrating on the most lucrative industries: currency, digital records, e-voting, supply-chain management, health etc. The personal applications are still in their infancy.

Applying blockchain technology to intangibles and to private use, as well as educating people to trust and use this new technology, are considerable challenges.

WHO IS WORKING ON THIS RIGHT NOW?

Many companies work on the digitization of stuff. Microsoft's Evoke Studio is working on a new digital memories service that is designed to change the way people preserve, organize, and access photos and videos. However; they work in silos as each company is focused on a specific area (e.g. capturing and digitizing memories, documents, 3D printing, etc.).

BREAKTHROUGH 16: AUTONOMOUSLY ADAPTIVE MATERIALS



Imagine an XPRIZE to create materials that change and adapt on their own to any condition and can serve as any structural or finish material in a house.

The adverse impacts of building materials to sustainability have raised global concerns. Housing companies must consider the resources that are being used to generate construction materials, the waste they generate, and the habitats they impact.

The winning team will develop a material that can change and adapt on its own based on external inputs like sunlight, temperature, or wind, to serve multiple functions within a home be it structural or finish.

Grand Challenge: Demographics, Affordability, Technology, Resilience
Level of Audacity: High
Market-Readiness Level: Low
Desired Timeline for Impact: 2030

WHO WILL THIS IMPACT?

Creating adaptive materials has the potential to impact all user groups.

WHY IS THIS IMPORTANT FOR THE PREFERRED FUTURE OF HOUSING?

The types and diversity of materials needed to construct homes are diverse and require a lot of expertise to install, maintain, and use for all of the purposes of a home. This XPRIZE incentivizes innovations in materials that can be both structural (strength, resiliency) and functional (transparent, colored, waterproof, etc.). Further, these materials could be adapted on the fly for another purpose in the house, allowing continuous updating of function while maintaining health and safety.

[192] Marc MacVean, "For Many People, Gathering Possessions Is Just the Stuff of Life," Los Angeles Times, March 21, 2014, http://articles.latimes.com/2014/mar/21/health/la-he-keeping-stuff-20140322.
[193] "The Self Storage Public Library," Self Storage Association, accessed December 16, 2017, http://www.selfstorage.org/library/public-library.

WHY DOES THIS WHITE SPACE EXIST AND WHAT CATALYST IS NEEDED TO CHANGE THIS?

Data and information regarding the hazardous and toxic waste related to sustainable building materials are insufficient. Debates about sustainable construction verses green construction added more complexities to the conversation surrounding building adaptation.

This whitespace is rapidly getting filled as experiments with new materials increase in R&D labs and universities around the world. With the convergence of multiple technologies, building materials will see a huge change in the next couple of decades. Nano- and micro-technologies will create a new genre of construction materials that are stronger, lighter, and smarter. In some cases, these materials will also be able to absorb, store, and discharge energy. Another trend that is rapidly emerging is the upcycling of waste materials, especially from the building sector, like recycled concrete, wood, construction rebar, and electric wires. But these experiments need an innovation catalyst to transcend the lab and get ready for commercialization at scale. Large-scale investment in successful experiments and the support of the construction and housing industry is the catalyst needed to get these experiments to market.

WHO IS WORKING ON THIS RIGHT NOW?

A number of industry leading firms like chemical company DuPont have research and development teams on the cutting edge of this issue. DuPont's newest project, Corian®, has developed materials with numerous applications ranging from exterior cladding, to countertops capable of wirelessly charging devices, to interior wall surfaces. Exploiting the special qualities of Corian®—translucency, vibrancy of color, extraordinary thermoformability—creative innovators are coming up with ever-exciting ideas for incorporating this versatile material in today's cutting-edge designs. Nonetheless this is one of only a few innovations in this space and the industry still lacks materials capable of adapting and serving multiple purposes without having to be deconstructed or re-engineered to support its new use.

Some companies have commercialized products capable of adapting based on ecological inputs like sunlight, but these products are limited to glass and building components with similar use cases. Saint-Gobain' SageGlass, a sustainability design company, uses electrochromic technology power to tint glass windows on demand—from a darkened state that absorbs and reradiates away the sun's unwanted heat and glare, to a clear state that maximizes daylight and solar energy. RavenWindow, a Denver-based smart glass company, uses a patented thermochromic filter directly incorporated into the windows during manufacturing that automatically transitions to a tinted state during hot conditions to manage solar heat flow, glare, and UV degradation and clears during cold conditions, therefore harvesting solar heat flow and light. Solar Activated Façade (SAF), a North American company that utilizes Swiss technology, has developed a cladding system that can absorb and store solar heat, thus creating a thermal buffer, which acts as a high performance insulation wall system.

The building blocks of the future are being developed in research labs today. From graphene production en masse to metamaterials that rethink the form and function of conventional construction mediums, there are several innovations with the potential to change the ways we build houses: unbreakable materials (e.g. precise polymer nanotrusses); resilient, self-cleaning finishes; wave benders; graphene; stronger concrete; natural concrete; synthetic spider silk; and improved wood.[194]

CONCLUSION

This report has mapped out many futures, both bright and bleak. The future that we finally arrive at will be determined by our approach today to the question of housing. Will we treat housing as a problem to be solved, or a market to be exploited? Will we treat housing as a privilege for the developed world, or a right for humans around the globe? Will we create homes that are static and atomized, or communities that are dynamic and connected?

Ideas alone are not the solution. They are an important first step, but a first step only. The world needs action, by leaders of industry and in the worlds of policymakers, financial institutions, and thought leaders. XPRIZE can provide the guideposts, but we need doers around the globe to step up if we ever want to reach them. We are at a crucial moment in the history of housing. The approaches we choose to act on or ignore today will have profound and lasting impact on industry, people, and the planet.

[194] Marc MacVean, "For Many People, Gathering Possessions Is Just the Stuff of Life," Los Angeles Times, March 21, 2014, http://articles.latimes.com/2014/mar/21/health/la-he-keeping-stuff-20140322.
[195] "The Self Storage Public Library," Self Storage Association, accessed December 16, 2017, http://www.selfstorage.org/library/public-library.
[196] "Dare to Be Dynamic," SageGlass, accessed December 16, 2017, https://www.sageglass.com/?gclid=CjwKCAiAoqXQBRA8EiwAIlOWsuM31YhiPOboRTgq3dwOZKoKMDDknV79E03Tn6Z6paeX_xlRDq-FxhoCkOkQAvD_BwE.; "Technology That Makes All the Difference," Raven Window, accessed December 16, 2017, http://www.ravenwindow.com/smart-window-technology.; "Home," Corian, accessed December 16, 2017, http://www.corian.com/.; Hallie Busta, "Five Innovative Building Materials Shaping the Future of Architecture," EcoBuilding, June 16, 2015, http://www.ecobuildingpulse.com/products/five-innovative-building-materials-shaping-the-future-of-architecture_s.; "New Building Materials for the Future of Construction, World Build, May 5, 2017, https://www.worldbuild365.com/news/iet0guhii/building-architecture/new-building-materials-for-the-future-of-construction.

APPENDICES

APPENDIX A: HOUSING ISSUES ORGANIZED BY TRACKS

To ensure we explored all possible aspects of housing and adjacent issues, we organized our research, interview questions, and internal brainstorming sessions around five housing tracks that each included multiple topics. Although we ultimately decided not to use this organizational structure in our final report and Futures ImpactMap, the tracks have nonetheless served as a useful framework for organizing our ideas and recommendations. The following table provides a more detailed description of the tracks and topics.

TRACKS	TOPICS	DEFINITION	EXAMPLES AND NOTES
Design	Materials	Physical materials used to build, assemble, or grow a home	Sustainably sourced, healthy materials, reusable materials
	Building Methods	Design, manufacturing, construction, and other approaches used to build, assemble, maintain, or gr ow a home	Process of building, lifespan of home, permanence, construction jobs, prostruction, resilience
	Forms	The size, shape, and function of different types of homes	Single family, multi-family, yurts, shared rooms, community gardens
	Beauty	Aesthetics of a home and the landscape	Design, architecture, form, cultural context
Money	Finance	Business models, financing mechanisms, and investment approaches to finance a home	Models for ownership, occupancy, renting, land tenure, permanence
	Resiliency and prosperity	The economic potential of a community and the individuals who live there	Growth, income, GDP, jobs, economic hubs, economy resiliency
	Affordability	The ability of individuals and families to access a home that meets their needs	Cost, proportion to other basic needs, subsidies
Community	Displacement and disruption	How to address problems related to acute or chronic needs for a home	Refugees, conflict, homelessness
	Urban development	How to address speed of growth and development of urban areas	Zoning, planning, multi-use, density, transportation, jobs
	Place	Feeling of identity and connection between yourself as a person, your home, and your community	Culture, social norms, social activities
Well-being	Safety	Sense of physical and emotional comfort and security created by a home	Shelter, protection, weather and physical elements, security, community relations, crime
	Health	Physical and mental health associated with your home	VOCs, sanitation, warm and dry, relaxation, leisure, family, open space
	Harmony	Balancing the relationship among humans and between humans and nature	Sustainability, livability, open space, green space, social interactions
Planet	Energy	How a home uses energy (electricity,heat)	Efficiency, demand management, integration with renewables
	Water	How a home uses water	Recycling, conservation, clean drinking water
	Footprint	The outputs of a home and impact of the home on the natural environment	Waste, wastewater, pollution, food, gardens
	Sustainability	The ability of a home to endure regardless of environmental changes	Climate, natural disasters, ecosystems, wildlife, biodiversity

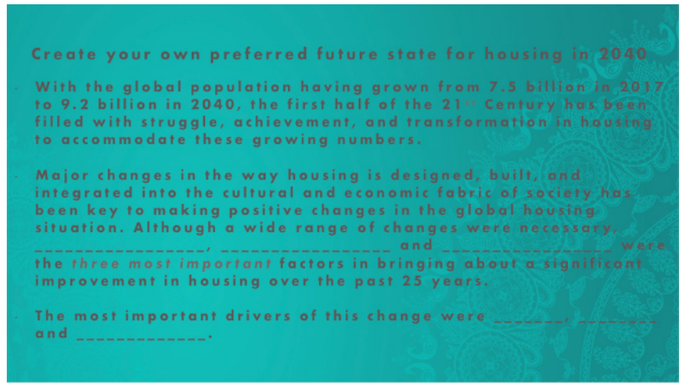
APPENDIX B: SELECTED CONTENT FROM HOUSING FUTURES IMPACTMAP LAB #1

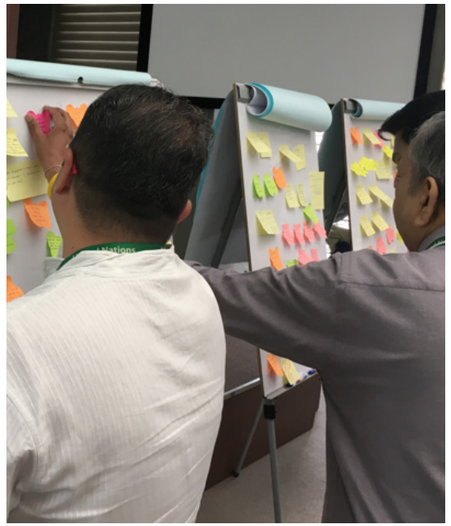
On June 14, 2017, XPRIZE, in conjunction with Lowe's, held a one-day interactive lab at the U.N. in Delhi, India. The purpose of the lab was to engage experts in a discussion about radical innovations to reshape the future of housing and benefit of humanity.

Fifty-six individuals participated, representing industries, government, academia, NGOs, investors, real estate development, architecture, and urban planning. These individuals participated in three facilitated, immersive exercises focused on:

- Developing a narrative to describe the preferred future of housing
- Creating scenarios to illustrate the preferred future and identifying breakthroughs in technology, markets, and policy needed to achieve it
- Identifying the sequence of actions necessary to incentivize breakthroughs by backcasting, or, in other words, considering the steps from the breakthrough being achieved back to the present

A selection of materials and photographs from the lab are included below. Participants used cards with examples of city archetypes and exponential technologies to build their vision for the future of housing.





APPENDIX C: SELECTED CONTENT FROM FUTURES HOUSING IMPACTMAP LAB #2

On November 6, 2017, XPRIZE, in conjunction with Lowe's, held a one-day interactive lab in Boston, MA as part of the Greenbuild International Conference and Expo. The purpose of the lab was to critique, validate, and further contribute to the research produced by the XPRIZE team.

Thirty individuals participated, representing industries, government, academia, NGOs, investors, materials science, architecture, and design. These individuals participated in three facilitated, immersive exercises focused on:

- Critiquing and validating a select number of breakthroughs that XPRIZE identified as key to achieving our preferred future state for housing
- Contributing new breakthroughs
- Identifying those breakthroughs that have the potential to be most impactful, and are best suited to move forward in the XPRIZE process

A selection of materials from the lab is presented below.

STAKEHOLDERS TO ACHIEVE THE MOONSHOT

- Many stakeholders are needed to drive changes that enable a moonshot to be accomplished, and many more are needed to ensure the moonshot has global impact. As you design the house of the future, make note of those critical stakeholders that are crucial in accomplishing the moonshot.
- Please fill out the types of entities represented in your designed house, and name specific organizations that might play a part. If you know of someone, please let us know that you can help by writing down your name.

Moonshot: _____

	STAKEHOLDERS		COMMITMENTS	
	Who are the types of entities that can help?	**What** will these stakeholders do to help achieve the moonshot?	**Which** organizations or individuals can be counted on to contribute?	**Name** of who can help us ensure they contribute.
Foundation The most critical stakeholder for ensuring this moonshot				
North Wall A crucial stakeholder for ensuring this moonshot.				
East Wall A crucial stakeholder for ensuring this moonshot.				
South Wall A crucial stakeholder for ensuring this moonshot.				
West Wall A crucial stakeholder for ensuring this moonshot.				
Roof Who can ensure the breakthrough scales to positively impact billions?				

Answer the following questions that help to determine if each moonshot really is necessary for accomplishing the Preferred Future State.

EVALUATING A MOONSHOT:	ANSWERS:
Which grand challenges does this address?	
How does this help achieve our preferred future?	
Is anyone else likely to do this? If so, who?	
What other things must occur beforehand to make this moonshot successful?	
What must happen after the moonshot to ensure global impact?	
When is this moonshot needed? By what year?	
Is an XPRIZE truly needed? Why or why not?	

LOWE'S XPRIZE

THE FUTURE OF HOUSING

Fill out the following word game to share how this breakthrough will truly achieve a moonshot.

The breakthrough of _____ is truly a moonshot worthy of being launched as an XPRIZE.
(Name of breakthrough)

Once this moonshot is achieved, it will support the journey to our preferred future by

_____. The impact this moonshot will generate will address
(Describe what will change to support the preferred future)

several grand challenges, notably _____ and _____.
(Grand challenges addressed with this breakthrough)

There is important work underway that supports this moonshot, such as

_____ and _____. But the moonshot
(Relevant efforts, technologies, policies, investments that relate to this breakthrough)

is unlikely to happen without an XPRIZE because _____,
(Innovation too slow, traditional players won't do it, lack of)

and _____. We know that the traditional solvers, such as
(Incentives, economic or policy barriers)

_____ and _____ will not accomplish this
(Government, Industry, NGOs, Academia, or other)

moonshot in time to achieve the preferred future because _____.
(Explain what prevents traditional actors from solving the problem)

APPENDIX D: SELECTED DATA FROM FLOATING KNOWLEDGE

XPRIZE commissioned Floating Knowledge to create and manage a virtual community to contribute to the Housing Futures ImpactMap. Over a period of five months, these experts, selected by XPRIZE, engaged in various online activities, including forum discussion, scenario generation, and red-teaming of scenarios and surveys, all of which yielded valuable insights for our work.

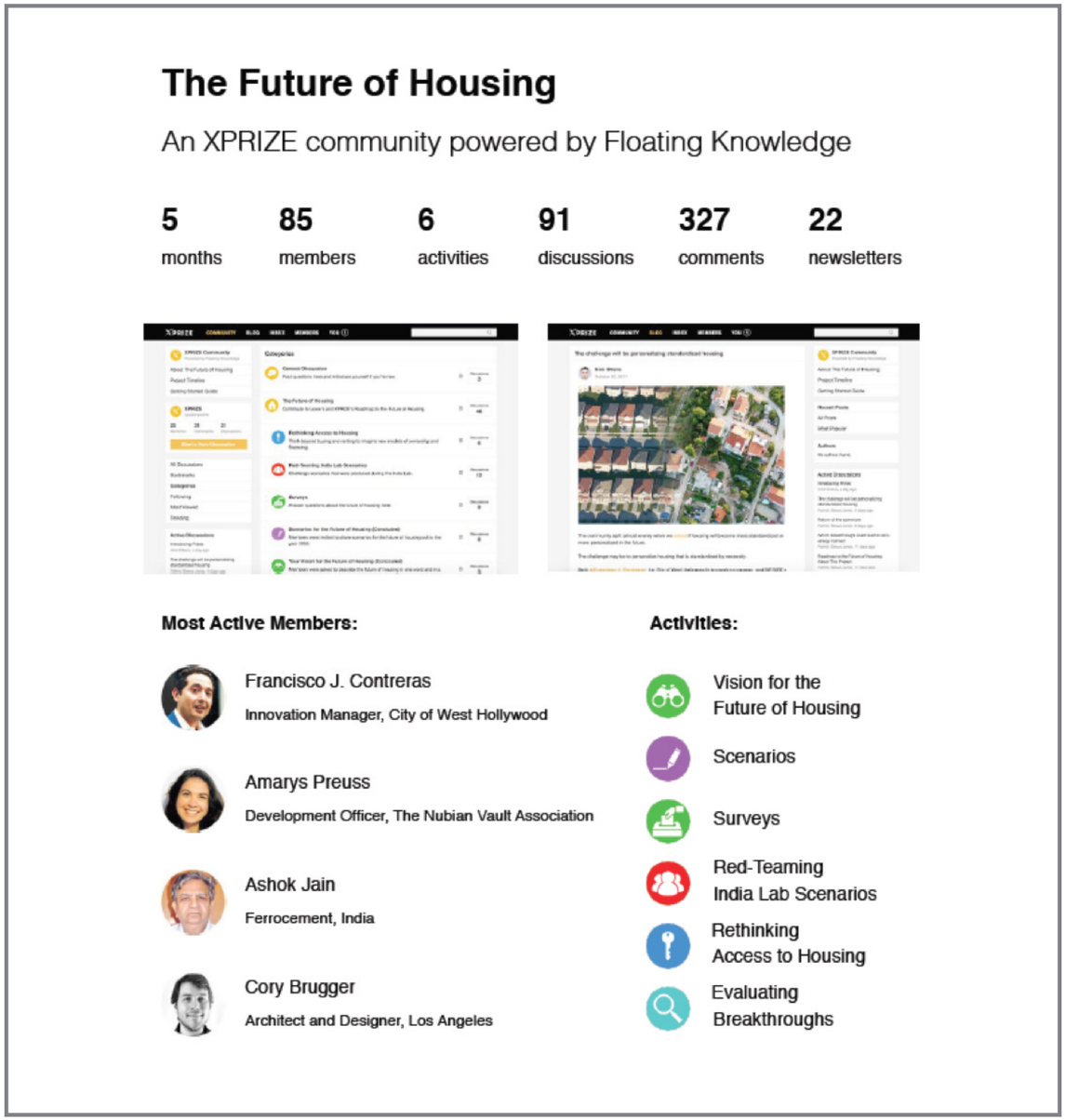
As of March 2018 the community consists of 85 members who have posted 288 posts across 88 topics. Members had the ability to initiate their own conversations, reply to others, "like" posts, and send private messages. Floating Knowledge also updates users on the latest activity through a regular newsletter.

Example engagements include:

- A red-teaming of scenarios that were developed during the XPRIZE India Lab, in which members challenged assumptions and identified weak spots.
- Discussions of the impact of climate change on coastal cities and how future homes might transcend geographical boundaries and the sharing of living space.
- Polls about breakthroughs that could lead to zero-energy homes and modularization as a solution to affordable housing.

- A challenge to rethink access to housing in which members looked at crowdfunding, 3D printing homes, 21st-century communes, and company towns.

A variety of ideas, scenarios, and quotes from members of the community have been incorporated into this report.



APPENDIX E: VISIONEERS SUMMIT 2016 AND 2017

"Imagine buildings that grow into fully inhabitable structures that can heal, generate energy, and clean the air."

That was the vision that the Healthy and Safe Homes Visioneers Team, sponsored by Lowe's, asked of approximately 250 mentors at the XPRIZE Visioneers Summit in October 2016. Beginning with the problem that current construction methods are wasteful, energy intensive, and usually involve building materials that negatively impact human health, they designed a prize concept focused on creating paradigm shift in the way houses are built in the 21st century. By merging the domains of the physical, the digital, and the biological, the prize sought to incentivize solutions that address this problem at its root, ensuring truly healthy and sustainable buildings in the near future.

Although the prize was not considered ready to launch at the summit, XPRIZE and Lowe's agreed to collaborate on a broader discussion of the future of housing that resulted in the development of this ImpactMap.

APPENDIX F: EXPERTS CONSULTED

The following is a list of experts who graciously provided guidance and input on the topics covered in this report and the Housing Futures ImpactMap. However, the conclusions and content within this report are those of XPRIZE and do not necessarily reflect the opinions of the individuals listed. XPRIZE is grateful for the time and insights of all of the experts who participated in this process.

NAME	ORGANIZATION
Fanyu Lin	Fluxus
Mike Zuckerman	Freespace
RJ Miller	GHC Housing Partners
Walker Wells	Global Green
Mili Majumdar	Green Business Certification Institute
Vien Truong	Green for All
Hilary Noll	First Community Housing
Rajesh Goel	Hindustan Prefab
V.Suresh	Hiranandani Constructions
Usha Prasad Mahavir	Housing and Urban Development Corporation
Akshaya Kumar Sen	Human Settlement Management Institute
Patrick Jones	IA Collaborative
Vaibhav Agarwal	ICICI Bank
Nirmala Singh	IKEA India
Saiba Suri	IKEA India
Vipin Sharma	Indian Institute of Technology Delhi
Amit Sethi	Indian Institute of Technology Guwahati
Sergio Palleroni	Institute for Public Interest Design
Arumugham Shankar	Jones Lang LaSalle
Steve Glenn	Living Homes
Melissa Fernandez	London School of Economics
Richa Misra	Lowe's Home Improvement
Gretchen Lopez	Lowe's Innovation Labs
Amanda Manna	Lowe's Innovation Labs
Kyle Nel	Lowe's Innovation Labs
Vaibhav Jambhekar	Mahindra Lifespace Developers
Amita Goel	Morphogenesis
Manit Rastogi	Morphogenesis
Cory Brugger	Morphosis
Anurag Gogna	National Institute of Construction Management and Research
Arnab Kumar	National Institution for Transforming India (NITI Aayog)
Amarys Preuss	Nubian Vault Association
R.V. Verma	Pension Fund Regulatory and Development Authority (PFRDA)
Gaurav Shorey	PSI Energy
Rachita Misra	Selco Foundation
Surabhi Rajagopal	Selco Foundation

NAME	ORGANIZATION
Ruchin Chaudhary	91springboard
Vishnu Padmanabhan	The Abdul Latif Jameel Poverty Action Lab
Anjanette Green	A Greener Space
Veronica Siranosian	AECOM
Ashok Lall	Ashok B. Lall Architects
Peter Verwer	Asia Pacific Real Estate Association
Mudit Narain	Atal Innovation Mission
Tanya Shanti Spisbah	Australian High Commission
Amit Sharma	Axiom India
Elsa Favreau	Bouygues Construction
Rajesh Krishnan	Brick Eagle
Vatsal Bhatt	Brookhaven National Laboratory
Pliny Fisk	Center for Maximum Potential Building Systems
Rhea Silva	Chototel
Veronika Bylicki	City Hive
Vera Baboun	City of Bethlehem (former Mayor)
Marissa Aho	City of Los Angeles
Ashley Atkinson	City of Los Angeles
Ted Bardacke	City of Los Angeles
Ben Winter	City of Los Angeles
Carl Hansen	City of Santa Monica
Rod Gould	City of Santa Monica
Francisco Contreras	City of West Hollywood
Ashley Hand	CityFi
Jared Levy	ConnectHomes
Aanand Kumar Singh	Construction Skills Council of India
Jancy Mathew	Construction Skills Council of India
Ajay Durrani	Covestro
Epi Ludvik Nekaj	Crowdsourcing Week
Kelsea Crawford	Cutwork
Aastha Saxena	Development Alternatives
Astha Saxena	Development Alternatives
Pratibha Ruth	Development Alternatives
Sanjay Seth	The Energy and Resources Institute
Ashok Kumar Jain	Ferro Cement
Hilary Noll	First Community Housing

NAME	ORGANIZATION
Prerna Kuhad	Shubhashray Housing India
Elizabeth Baca	State of California, Office of Governor Jerry Brown
Maureen Mahle	Steve Winter Associates
Meredith Adler	Student Energy
Braeden Peterson	Students for Humanity
Arun Kashikar	Tata Housing
Pooja Juneja	Tata Steel
Maria Aiolova	Terreform ONE
Alison Mears	The New School
Rajneesh Chowdhury	The Practice
Bhara Kundrat	The Practice
Vivek Rana	The Practice
Nabila Jamshed	United Nations
Gregor Herda	United Nations Human Settlements Programme
Hitesh Vaidya	United Nations Human Settlements Programme
Yuri Afanasiev	United Nations Development Programme
Gauri Arora	United Nations Development Programme
Radhika Kaul Batra	United Nations Development Programme
Ruchi Mohanty	United Nations Development Programme
Alka Narang	United Nations Development Programme
Suneel Padale	United Nations Development Programme
Eva Kaplan	United Nations International Children's Emergency Fund (UNICEF)
Brenden McEneaney	U.S. Green Building Council
Penny Gurstein	University of British Columbia
Priya Sreedharan	United States Agency for International Development (USAID)
Elaine Hsieh	VERGE GreenBiz Group
Vasudha Thawakar	World Bank
Utkarsh Amitabh	World Economic Forum
Jyot Chadha	World Resource Institute
Tom Hunt	X, The Moonshot Factory
Viola Gauci	X, The Moonshot Factory
Rahul Batra	Yunus Social Business India
Aarti Wig	Yunus Social Business India

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