2013

Designing Affordable Housing for Adaptability: Principles, Practices, & Application

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In partial fulfillment of a Bachelor of Arts Degree in Environmental Analysis,

2012-13 academic year, Pitzer College, Claremont, California

Readers:

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Deepest thanks to my readers, Lance Neckar and Paul Faulstich, as well as Brinda Sarathy. Thank you for your inspiration and advice throughout the development of this project, and for enabling and fostering my somewhat unconventional approach.

To my loved ones, thank you for the relentless support and confidence you have given me, and for always keeping me grounded in some way or another.

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Chapter I. Introduction

In the realm of architecture and urban planning in the western world, sustainable development is no longer perceived as a novel idea pertinent to only certain locations, populations, or building typologies. Many standards of building and development are changing across the board. It is no longer environmentally or economically feasible to continue past trends of energy and resource consumption for constructing and operating the built environment.

While environmental and economic sustainability have been driving factors in the movement towards a more resilient built environment, the importance of social sustainability is another factor that has received significantly less attention over the years. Typically, only affluent populations have had access to environmentally sustainable building solutions, which in turn provides more economically sustainable living situations those that already have money. Meanwhile, populations of lesser affluence have not had the opportunity to invest in more environmentally sustainable endeavors, and are stuck paying high energy and water prices that others are able to avoid. The result is a state of social inequality that is even worse than before the growing trend of sustainable building practices.

This situation is particularly problematic in the case of publicly subsidized affordable housing in the United States. In affordable housing projects, tenants have no means to invest in sustainable solutions on their own, and the funds rarely exist to make substantial building wide upgrades. Federal support for low-income housing has fallen 49 percent from 1980 to 2003, causing about 200,000 rental housing units to be destroyed annually (National Low Income Housing Coalition, 2005). This exacerbates the inefficiency of pouring already menial funding into the high cost of resources. Environmentally sustainable affordable housing would be more economically sustainable and therefore free up more resources to help reduce social inequalities in the long run.

Additionally, health conditions are another social inequality that have proven to be greatly dependent upon environmental conditions—conditions that are often controlled by the building in which one lives and works. Inadequate and poor quality housing contributes to health problems such as infectious and chronic diseases, injuries, and poor childhood development. Families with fewer financial resources are most likely to experience unhealthy and unsafe housing conditions and typically are least able to remedy them (Commission to Build a Healthier America, 2008). Like most issues discussed here, unhealthy environmental conditions are not only a problem of social sustainability, but also have inefficient economic outcomes.

However, there is simply not enough well-designed affordable housing. One-fourth of all American households—approximately 30 million families—lack access to adequate housing (Dorgan and Evans, 2008). The demolition of existing affordable housing to make way for new development caused this deficit to increase from 2008 to the present (Bolton, 2013). For example, in Alexandria, VA, 2,500 affordable housing units will be torn down in the next 30 years and replaced with condos, shopping centers, and only 800 affordable units (Stone, 2013). This is happening in cities all over the country, leaving many residents without housing options (Bolton, 2013).

How can architects design affordable housing that is intrinsically sustainable? Sustainable technologies generally have much higher upfront costs and do not seem feasible in the planning of affordable housing projects. Incorporating current sustainable technologies is often deemed unrealistic because affordable housing has never been designed to last. In the past, subsidized low-income housing has been built as if to provide a short-term solution—as if poverty and lack of affordable housing is a short-term problem. Confronting this issue requires affordable housing developments to last into the future without becoming obsolete, and this requires adaptation. The incorporation of adaptability in architecture is essential for the design of affordable housing that is environmentally, economically, and socially sustainable. Architects must balance affordability, durability, and adaptability to design sustainable solutions that are resistant to obsolescence.

Chapter II. Background

Limitations not considered, every building is adaptable and every building is affordable. However, the world is full of limitations, so an investigation of the measures of adaptability and affordability requires rigor. Adaptable and affordable must be defined in the context of existing limits.

Defining Adaptable

Adaptable describes something capable of being or becoming fit (as for a new use) often by modification. Scholars have proposed many different definitions of what the term 'adaptable housing'. Avi Friedman suggests that 'providing occupants with forms and means that facilitate a fit between the space needs and the constraints of their homes either before or after occupancy' (Freidman, 2002) is one interpretation of adaptability. By including '*either* before *or* after occupancy' in the definition, Friedman's definition encompasses housing adapted for occupants' original needs, but does not require that housing to be adaptable for future needs. Friedman's definition of adaptability is widely contested for this reason. For example, in the AdaptableFutures project, Schmidt and colleagues identify four characteristics that must be included in the definition: "*capacity for change*, ability to *remain 'fit' for purpose,* maximizing *value*, and *time* (*speed of change* and *through life changes*)." As their working definition of adaptability, AdaptableFutures generated 'the capacity of a building to accommodate effectively the evolving demands of its context, thus maximizing value through life' (Schmidt et al., 2010). Although Friedman's definition of adaptable would include some buildings that Schmidt and colleagues would *not* classify as adaptable (in the long term), these definitions are similar in that they both describe buildings that fit or accommodate the occupants or context of that building at some point in time.

The term flexible further complicates interpretations of the term adaptable. Schneider & Till define flexible housing as 'housing that can adjust to changing needs (personal, practical or technological) and patterns (demographic, economic, or environmental), both social and technological' (Schneider & Till, 2007). Like Friedman, Schneider & Till also include pre-occupation flexibility in their discussion, but the focus clearly lies in post-occupation flexibility. For example, Schneider & Till argue that long term flexibility allows housing providers to adapt the mix of unit types, to change internal layouts, and to upgrade their property in an economic manner (Schneider & Till, 2007). This argument resonates more closely with Schmidt et al.'s definition for the AdaptableFutures project.

In their definition, Schneider & Till further discuss different types of flexible housing according to the use of "soft" or "hard" tactics. Soft tactics are those that allow a certain indeterminacy, such as the provision of a room with an indeterminate function. Contrarily, hard elements, such as sliding or rotating walls, are those that more specifically determine the way that the design may be used (Schneider & Till, 2007). The authors also apply this "soft" vs. "hard" terminology to technologies and construction methods used in adaptable housing. These different terminologies are relevant in this investigation of adaptable, affordable housing, because, although architects' natural tendency is often towards hard elements of design and technology, perhaps further benefits may be achieved affordably using soft tactics.

If one were purely investigating types of adaptable and flexible housing, it may make sense to clearly define a difference between the two terms. However, for the purpose of this investigation adaptable is used to address both issues of flexibility and adaptability since in relation to affordable housing, their definitions and functions are for the most part indistinguishable.

Defining Affordable

Affordable describes anything capable of bearing cost without serious detriment. Of course, this definition is entirely subjective; what is affordable to one person may not be affordable to another. Due to this subjectivity a clear definition of affordable housing is difficult to pin down. In an attempt to take an objective approach to the issue, various metrics have been utilized to assess affordability. . Income is the main factor that determines whether or not housing is affordable, which means that 'affordable' has a different interpretation for every individual regardless of the relative intrinsic flexibility or adaptability of housing. Although no consensus exists on how exactly to measure housing affordability, most [government officials, researchers, property managers etc.] gauge affordability based on housing expenditure-to-income ratios (Carswell, 2012). Housing expenditures include the cost of rent plus the total cost of utilities (gas, oil, electricity, other fuel, water, and trash collection) (Vandenbrouke, 2011). According to this measure, affordability is defined as housing that does not exceed more can 30 per cent of the occupants' income. David Hubchanski argues that while the 30 percent rule is a reliable quantitative indicator in housing research and administration, it is an invalid and misleading measurement for defining housing need (to inform public policy), predicting ability to pay for housing rent or mortgage, and as selection criteria in decisions to rent or to provide mortgages (Carswell, 2012). Acknowledging the flaws present in this measurement, other measures have been developed in an attempt to create breadth in understanding of affordable housing.

The National Low-Income Housing Coalition has developed the *housing wage* metric. The *housing wage* gives an estimate of how many hours per week and the hourly wage a worker needs in order to afford both rental housing at the fair market rate (FMR) and utilities without paying more than 30 per cent of income on the housing (Carswell, 2012). The National Association of Realtors (NAR) Housing Affordability Index measures whether a typical family (one earning the median family income as reported by the U.S. Bureau of the Census) could qualify for a mortgage loan on a typical home (the national median-priced, existing family home as calculated by the NAR) (Carswell, 2012). This measurement lacks sufficient specificity to be useful, however, because it neglects to address regional variations in prices and income as well as commuting choices and energy prices. Further, various industries have developed housing affordability measures used as general market indicators for lending, real estate, and building industries, which are also used in policy (Carswell, 2012). These different measurements exemplify cross disciplinary interpretations of housing affordability, which interpretations are relevant to conceptualize affordable housing as an interdisciplinary field of research.

Although the conventional 30 percent rule is imperfect, as Hubchanski revealed, most literature, and HUD, continue to use this measurement. Walker Wells reiterates the practical significance of this measure in his definition of affordable housing:

> Affordable housing includes rental, for-sale, co-, and transitional housing that is income restricted and usually developed through one or more forms of public subsidy. Affordability is achieved by setting the monthly rent or mortgage payment in accordance with the resident's income (no more than 30 percent of their gross income), rather than at market rates (Wells 2010).

This definition also makes the inevitable connection between affordable housing and public subsidy. Over the past decades, working wages have increased at a much slower rate than inflated housing costs (Friedman, 1992; NLIHC, 2005), thus generating a large low income population that is far from able to afford market rate housing. To account for this gap, affordable housing is usually funded through a combination of tax credits, preferential debt, grants, and other government subsidies (Wells, 2010). Public subsidy is necessary to create affordable housing, but government officials are beginning to realize that other factors (i.e. energy efficiency) should be included to calculate the true affordability of that housing.

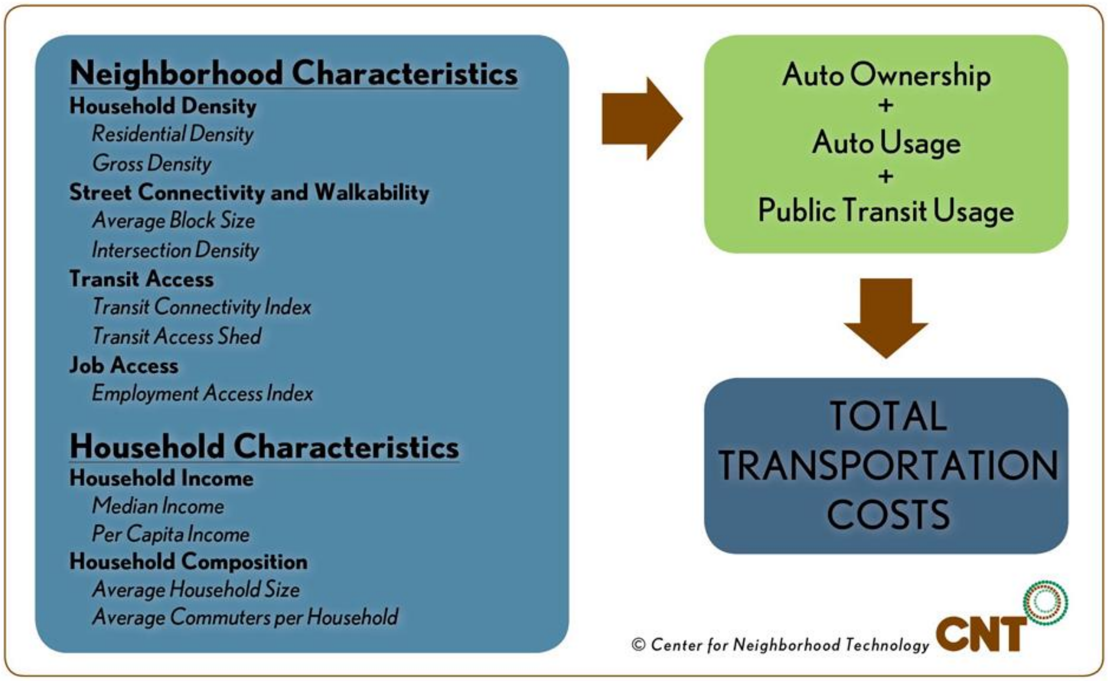

Figure 1. Total Transportation Cost Calculation (htaindex.cnt.org)

Location efficiency is one of these factors that been researched more thoroughly in the last ten years. Transportation costs vary between and within regions depending on neighborhood characteristics (Figure 1).

People who live in location-efficient neighborhoods—compact, mixed use, and with convenient access to jobs, services, transit, and amenities—tend to have lower transportation costs. People who live in location inefficient places that require automobiles for most trips are more likely to have high transportation costs (htaindex.cnt.org). According to HUD, these costs are not easily discernable like monthly rent, so they have not yet been concretely integrated into HUD programs and policies, however, HUD's Office of Sustainable Housing and

Communities has created the federal Housing and Transportation Affordability Initiative to fill this information gap (portal.hud.gov). Alternatively, The Center for Neighborhood Technology has found 15 percent of income to be an attainable goal for transportation affordability. Their Housing and Transportation Affordability Index proposes to expand the definition of housing affordability to include transportation costs, together consuming no more than 45 percent of household income (H+T Index, 2012). For the purpose of this research, this 45 percent definition will be used to define affordable housing. This definition is more holistic, especially when thinking in terms of sustainability. Further, the design proposal that is a product of this research is located along a new public transit corridor, so transportation costs are essential to determine true affordability and sustainability of the project.

History of Adaptable Housing

Adaptable housing is beginning to be interpreted in new ways, but it is by no means a novel idea, especially as a tool to make economical design more livable and usable. Schneider & Till suggest two scenarios for the development of flexible housing in history. The first indicates that development came as a result of evolving conditions in vernacular housing—"embodying means that are in balance, readily available, appropriate to the local economy, open and therefore easily adaptable to changes in use and occupation" (Schneider & Till, 2012). Vernacular architecture tends to be very adaptable. Usually constructed by hand using local materials, structures can be easily added on to or demolished and recycled naturally. This contrasts greatly with the "fixity" of so much architect-designed housing in contemporary western cultures, in which the response to changing family sizes is to sell up and move on—the least responsive and most expensive option (Schneider & Till, 2007). Although adaptability in the form of the vernacular is not exactly applicable to contemporary modern architecture, vernacular architecture offers many insights into the ways that a building might naturally evolve over time—expanding to fit its occupants, shedding or gaining layers through different seasons, etc.

The second, more relevant version in the context of policy formation and broader development of design principles, developed in response to external pressures that have prompted housing designers and providers to create alternative design solutions. This is the contemporary version of adaptability involving architects and other experts. Schneider & Till propose three key drivers in the development of contemporary adaptable housing. These different phases are particularly important for this investigation of affordable housing, because they illustrate the early alignment of adaptability in social housing, where they began to diverge, and later movements to realign the two concepts.

The first phase came about in the 1920's (following the First World War) in response to the need for European social housing programs to provide mass housing for the working class. In order to supply housing to as much of the population as possible, smaller space standards were adopted. Schneider & Till term this phase "modernity and the minimal dwelling," arguing that early modernist architects sought to make these minimal dwellings as functional as possible using elements of adaptable design (Schneider & Till, 2007, 2012). Dutch architects such as Johannes van den Broek experimented with changeability of use—over the course of a day, for the specific conditions of each family member, and for potential changes during their lifetime. More specifically, Mart Stam examined the daily cycle of a family over the course of 24 hours. He concluded that, because some rooms went unused for much of the day, these spaces should afford different uses during that time (Schneider & Till, 2007). For example, a bed could fold up to provide additional living room or office space during the day. These findings produced varying degrees of adaptable housing. In the Schröder Huis, designed by Gerrit Rietveld in close collaboration with the client, a complex system of sliding walls and folding screens adapted to suit the daily cycles of the family. Alternatively, Bruno Taut's design for a Berlin apartment complex in 1925, called the Hufeisensiedlung ("horseshoe colony"), provided indeterminate rooms (Figure 2)—rooms of similar in size and non-hierarchical in layout—so the residents could adapt the functions to fit their needs (Schneider & Till, 2012). Further, functionally-tailored semi-public spaces, such as allotment gardens, fostered flexibility at a community wide scale while also allowing residents to grown their own food and augment housing costs with self-grown produce.

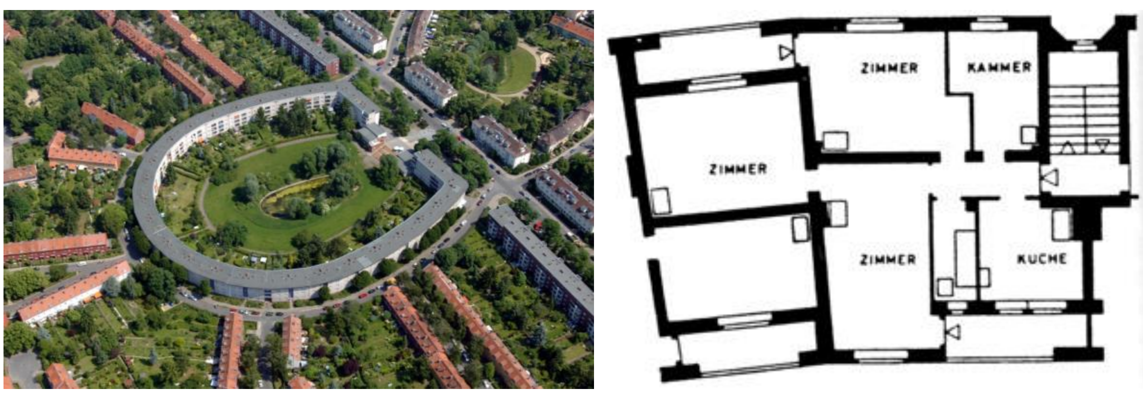

Figure 2. Hufeisensiedlung, Berlin, 1925 Aerial Perspective (left) and Exemplar Unit Plan (right) (Schneider and Till 2006)

The second phase in the evolution of adaptable housing began in the 1930's – 40's and was essentially based around the belief that flexible housing could be available to all by means of prefabrication and other emerging technologies (Schneider & Till, 2007). This phase must be further categorized into two different processes. The first came from the ideas of architects like Le Corbusier and Walter Gropius, who were both proponents of modularity and standardization, because it was inherently flexible. Gropius argued that standardized components and production should be utilized not only to provide clients with multiple options in the initial stages of design, but that those components would also allow adaptation over time (Schneider & Till, 2007). Unfortunately, what evolved out of this time period was not what Gropius and Le Corbusier envisioned. New systems of production enabled the manufacture of ever-larger prefabricated parts, and eventually, entire houses that could be built according to the desires of the client, such as Cliff May Ranch Homes (Figure 3).

Figure 3. Cliff May Lakewood Rancho Estates (prefab development), Long Beach, 1953

To this day manufactured house production continues to provide a customizable and affordable choice for housing. Many new prefabricated building systems even utilize sustainable, recyclable parts. However, as Schneider & Till point out, although the user is provided with a wide range of short-term design decisions, this kind of manufactured home limited in terms of future change.

The third phase began in the 1960's and 70's when the move toward participation and user involvement led to a renewed interest in adaptable housing as a means of providing user choice (Schneider & Till, 2007). John Habraken's *Supports: An Alternative to Mass Housing* was a seminal piece of literature during this phase. He advocated for the building of "supports", which consist of the primary structure, the building envelope, circulation spaces, and mechanical systems. These supports can then be infilled by occupants in a systematic order to accommodate a variety of floor plans and features (Habraken, 1972). What arose from this discussion was the concept of Open Building, which Habraken uses to indicate a number of different, but related ideas about the making of the environment. For instance:

- Distinct levels of intervention in the built environment, such as those represented by 'support' and 'infill', or by urban design and architecture.
- Users / inhabitants may make design decisions as well.
- More generally, designing is a process with multiple participants also including different kinds of professionals.
- The interface between technical systems allows the replacement of one system with another performing the same function (As with different fit-out systems applied in a same base building.)
- Built environment is in constant transformation and change must be recognized and understood.
- Built environment is the product of an ongoing, never ending, design process in which environment transforms part by part (www.habraken.com).

Habraken's emphasis on the dynamic nature of the built environment is important because it demonstrates that adaptability does not need to be an abstract concept but rather it serves as an inherent part of social context and processes (Schneider & Till, 2007). Since the era of *Supports*, Habraken's ideas for residential open building practices are being adopted for use more frequently, especially in Finland, Japan and the Netherlands (Kendall, 2011). One successful example of government-subsidized open building is Gespleten Hendrik Noord (Figure 4), built in Amsterdam in 1996.

Figure 4. Gespleten Hendrik Noord Floor Plans (upper) and Street Perspective (lower) (Schneider and Till 2006)

The design process was broken down into two stages. First, future residents discussed general functions, layout and priorities of the complex. Next, the architect and the contractor consulted closely with individual occupants to design 28 unique units within the support structure. The easily adaptable layout and function of the units allows for a diversity of floor plans, finishes, and complementary uses—making high long-term value intrinsic to the complex (Kendall, 2011). Participatory design, although more frequent in recent years, is still rare to the degree that open building principles encourage. Open building allows for unique, user-determined infill within a standardized system so it can be easily adapted in the future.

Adaptable housing clearly has a very interestingly intertwined history with affordable housing. Adaptable architecture first originated as a necessary solution to make affordable housing functional and livable, but it was also fetishized as form of minimalist modernism. Later, architects including Gropius and Le Corbusier saw emerging production technologies and thought these could be used to design customizable and continually adaptable housing that would be affordable to the masses. What resulted instead were easily affordable, prefabricated housing elements with a planned obsolescence. Finally, by the time Habraken was advocating for open building, adaptability had been so far removed from affordable housing that it would have been extremely difficult to build subsidized housing using open building practices. Although open building argued for user participation, the user still had to be able to afford to participate. It is important to note that the three drivers discussed in this section (housing demand & limited space standards, new methods of construction, and user participation) still exist today at the forefront of the contemporary housing agenda (Schneider & Till, 2007). In the end, the good intentions of early modernist architects to create high quality, adaptable, affordable mass housing came at too high a price in competition with cheap prefabricated goods. Affordable housing has since largely been trapped by the cycle of prefabricated housing and parts—cheaply built, unable to adapt, and therefore doomed to deteriorate or become obsolete. The following chapter discusses why this had been problematic for affordable housing and how adaptability is one design solution to the mass housing crisis.

Chapter III. Why should affordable housing be adaptable?

It is impossible to come up with one overarching solution to solve all of the problems involved in the world housing crisis today—joblessness, poverty, homelessness, and access to adequate shelter are all part of this seemingly never ending battle. In a time when 30% of the world's urban population resides in squatter settlements, 90% of whom are in the developing world (UN-HABITAT, 2008), the argument to design buildings with adaptability in mind to improve the quality of affordable housing in a developed country like the United States may seem trivial. Instead, one must recognize that this specific discussion resides within a much larger crisis of unequal wealth distribution leading to inadequate provision of goods to a huge percentage of the population.

Obsolescence

The magnitude of the crisis described above demonstrates that as long as humans continue to live on Earth, there will be a need for affordable housing—housing that receives one or more form of public subsidy. For a typology of building that will be around forever, the most overarching argument that affordable housing should be designed for adaptation is to combat obsolescence. *Obsolescence* is a condition of being out-of-date, or old-fashioned, and implies that something continues to function, albeit at levels below contemporary standards. Obsolete things (in this case, buildings) will be used until they fail completely to function as required or the disadvantages of their continued use outweigh the costs of their updating, retrofit, or replacement (Lemer, 2012). In an ideal world, all products would be designed to resist obsolescence, but this is not the case in the existing market.

Housing is particularly vulnerable to obsolescence for a couple of reasons, according the Schneider & Till. First, housing is "volatile, subject to a whole range of cyclic, and non-cyclic changes." They argue that the other main reason is economic. Consumers accept and even thrive upon planned product obsolescence—meaning that products are expected to fail and be replaced. This model of planned obsolescence is ubiquitous in the design of both public and private housing. Therefore, "lack of investment in research and development has resulted in a house building industry that is unable to keep abreast of innovation in processes and technology or to cater for long term social needs (Schneider & Till, 2007)." This system is problematic for the building of affordable housing, because although built according to the existing private market conditions, subsidized projects do not have the funds to rebuild from scratch when something becomes obsolete.

This failure is evident in the history of public housing in the United States. Many would argue that publicly funded housing projects were (and still are, in some cases) detrimental to the wellbeing of those who reside there. Jasmine Edo argues that the architecture and environmental health of public housing developments combine to create communities with *socially excluded residents*—"residents who experience denial of social citizenship, or ability and freedom to participate in the economy, society or politics to certain groups due to processes of stigmatization and forms of institutional discrimination (Edo, 2011)." Edo makes a compelling argument that the government's inability to provide and maintain the physical condition of subsidized housing has resulted in a "structural inequality". Designing public housing projects to cater to the long-term social needs of future residents saves buildings *and people* from obsolescence. Adaptable architecture makes affordable housing more resilient to obsolescence because it allows for the optimization of space—from the level of an individual unit to the building-wide level, and from one point in time to the entire lifecycle of the building. Further, planning for long term retrofits to mechanical and aesthetic systems is another valid technique for mitigating obsolescence. Together these factors maintain housing of increased value and consequentially residents with increased self-worth.

Optimization of Space

As discussed in Chapter One, architects first began designing adaptable housing as a tool to optimize space in public mass housing projects that allotted only the minimum space possible per unit. Naturally, optimization of space is still one of the most notable advantages of adaptable architecture. In an effort to provide "decent, safe and sanitary" housing, HUD identifies basic housing quality standards (HQS) which all units must meet before assistance can be paid on behalf of a family and at least annually throughout the term of assisted tenancy. In regards to "Space," the following must be met:

> "(1) *Performance requirement*. The dwelling unit must provide adequate space and security for the family.
> (2) *Acceptability criteria*.
> > (i) At a minimum, the dwelling unit must have a living room, a kitchen area, and a bathroom.
> > (ii) The dwelling unit must have at least one bedroom or living/sleeping room for each two persons. Children of opposite sex, other than very young children, may not be required to occupy the same bedroom or living/sleeping room (HUD, 2010)."

This definition leaves much open to be interpreted in the design of each unit. It also alludes to the issue of "fitness". Efficiency is extremely important in affordable housing, so the space of any given unit should be optimized according to the needs of the individual family that resides there.

This is a difficult problem, because the diversity of family typologies and household arrangements has increased greatly in the past fifty years. There is no longer a homogeneous, standard household unit in The United States. Single parent families, multiple family households, and other "non-traditional" living arrangements are now just as common as the former (Friedman, 2002). These trends, overlain with unseen and uncertain demographic developments, are likely to continue into the next decades (Schneider & Till, 2007). Similarly, increase in cultural diversity has generated a need for housing that can adapt to different privacy, space, and use requirements. Attenuation to cultural differences must be carefully considered in affordable housing, because many first, second, and later generation immigrants depend on those provisions. Therefore, a single residential unit will now have to accommodate a wide diversity of households over time (Friedman, 2002). This diversity should be accounted for early on in the planning process. Then in the event of a change, the unit can adapt to fit the user rather than force the user to adapt to a living situation that does not suit them.

Schneider & Till discuss two approaches to accommodate these changes. One can "cherry-pick one of the emerging trends and provide for it in the immediate term," such as "mirco-flats for key workers/young professionals." However, this approach is problematic, because it shuts down future options for adaptation (Schneider & Till, 2007). Alternatively, Schneider & Till argue for "an open future" that utilizes one of the following approaches.

The first approach, "the idea of base structures", provides a frame and within it empty generic space that can be infilled and adapted over time. This approach resonates strongly with Habraken's Open Building strategies, and was utilized in the NEXT 21 Housing Project in Osaka, Japan in 1993. Although NEXT 21 is a housing project funded by Osaka Gas Company, rather than a government subsidized project, it experimented with technologies and sustainable design methods quite advanced for its time. Although specific technologies may be dated, the systems utilized are extremely relevant to this research. Strategies to accommodate changing preferences and lifestyles of individual occupants as well as energy and resource conserving design strategies and building systems were experimented (Kim, Brouwer, & Kearney, 2011). One of these strategies is the base structure—columns and beams of cast-in-place concrete are the only part of building fixed permanently, and are expected to last 100 years (Kamo, 2000). The structure is modular and varies according to the type of space. Public zones, house zones, and street (circulation) zones, all consist of different modules that should accommodate changes in that typology of space. Modularity is the second crucial approach for optimization of space. It allows for easy adaptation and integration of other building layers: the exterior cladding, unit infill, and mechanical systems. House zones and street zones are indeterminate in their function and can be connected together in a variety of configurations, because of modular design rules (i.e. specified wall thickness and placement within grid). Modular coordination is similarly applied throughout each unit. One drawback of modular design is that it does require that components adhere to the prescribed module. However, Next21 exemplifies the uniqueness that can still be achieved within one system by contracting 13 different architects to work with future occupants to design 18 specialized units within the complex (Kim et al. 2011).

Long Term Retrofits

While optimization of space may have initially been the most important reason for adaptable housing, today, this is not usually the determining factor in the functional vs. obsolete discussion. Alternatively, often it is the mechanical systems that determine the performance of a building. Technology is changing at an exponential rate, meaning that more efficient water, energy, HVAC, and other systems are available every year. As these new technologies become more feasible to incorporate, building performance standards will undoubtedly become stricter. If these systems are not designed for adaptability, they will quickly push the building towards obsolescence.

At this point, affordable housing cannot afford to become obsolete. The funds to demolish obsolete housing projects and replace them with upgraded housing projects simply do not exist, and the environmental costs of frequent replacement are intensive. Like the problem of planned obsolescence discussed earlier, this is not economical and especially not sustainable. Government subsidized housing projects should be models of sustainable development—a testing ground for new technologies (like Japan's Next21 Housing Project and RenewTown)—not a dumping ground for old technologies, because they would be able to acquire first hand data and use those findings to immediately advance current programs and policies.

The problem of adaptable subsystems can be avoided using one characteristic of Open Building, as described by Kendall and Teicher in *Residential Open Building*. Subsystems should be coordinated for eventual change, thereby allowing them to be independently adjusted or replaced without disrupting other dwellings or subsystems. Further, "selecting 'open systems' with standardized technical interfaces, dimensions, and locations" allows for the adoption of any subsystem which adheres to industry wide performance standards. This way, subsystem choice can be "based on design, quality, service and other economic standards, rather than solely on functional compatibility (Kendall & Teicher, 2000)." There are many different approaches to designing adaptable systems within the building. Next21 coordinates mechanical systems as subsystems of other modular components discussed previously. Mechanical systems are concentrated in vertical shafts, rather than located within individual units. The ducts, pipes, and electrical wiring are arranged in an accessible grid system in the floor which allows not only wall partitions, but also kitchens and bathrooms to be flexible in their location (Kim et al., 2011) Mechanical systems generally have much shorter lives than the building frame, so organizing them in easily accessible subsystems allows for long term retrofits with prevent the building from becoming obsolete.

These same concepts should also be applied to aesthetic qualities of the building—such as wall paneling—to account for wear and weathering over time as well as changing trends. Another subsystem designed for adaptation in Next21 is the exterior cladding system. Exterior walls are installed in panels that can be changed from the inside, without the need for scaffolding. Further, individual unit facades (both walls and windows) are coordinated in a modular arrangement that can be varied while maintaining a unified appearance from the street (Kim et al. 2011).

Environmental Sustainability

The environmental argument for adaptable architecture is strongly supported by all of the factors discussed above. A longer overall life span reduces the need for demolition and new construction, which is extremely energy intensive and a waste of resources. Longer life span is only achieved by recognizing and coordinating systems effectively within the design. Breaking the building down into layers according to their expected life spans allows systems to be upgraded only as they become obsolete, not sooner or later, which is either wasteful or inefficient. Coordinated subsystems reduce the amount of waste during remodeling, because walls and floors do not need to be torn up, simply moved. Similarly, removed components can be stored and recycled throughout the building as needed. Easily retrofitted technological subsystems can be upgraded to meet environmental standards at minimal construction costs.

Economic Sustainability

Through avoidance of obsolescence, economic value is inherently added to affordable housing. The ability to adapt the layout of housing at different scales to optimize space, and the ability to continually upgrade and retrofit mechanical and aesthetic qualities of affordable housing are tools that create these values. However, as Schneider & Till point out, there is little quantitative data to support this argument:

> All our qualitative research indicates that if technological systems, servicing strategies and spatial principles are employed that enable the flexible use of a building, these buildings in turn will last longer, and they will be cheaper in the long run because they reduce the need and frequency for wholesale refurbishment… Market research in the Netherlands has shown that people are more likely to stay in their homes if they can adapt them, and by corollary high percentage want to move because they cannot adjust their dwellings to their needs… However, there is almost nothing in terms of hard-nosed financial assessments of flexible housing (Schneider & Till, 2007).

The economic value of adaptability, although it makes logical sense, has been very difficult to assess given varying degrees of adaptability, different systems, and simply lack of accurate record keeping. This is a likely explanation for the lack of research. Manewa, Pasquire, Gibb, and Schmidt III suggest a conceptual framework (Figure 5) that takes into account driving factors for change (economic, social, environmental, and obsolescence), solutions for change (new construction or adaptable building), and higher-level adaptability strategies (flexible, available, changeable, moveable, reusable, refittable, and scalable) to determine Whole Life Analysis (Manewa et al. 2009). In the affordable housing sector, whole life analyses would be extremely useful and revealing, because units need to be upgraded on a regular basis and the costs of management and refurbishment exceed the initial capital cost (Schneider & Till, 2007). This lack of past research makes it difficult to demonstrate that designing affordable housing for adaptability is actually more economically sustainable than other design models.

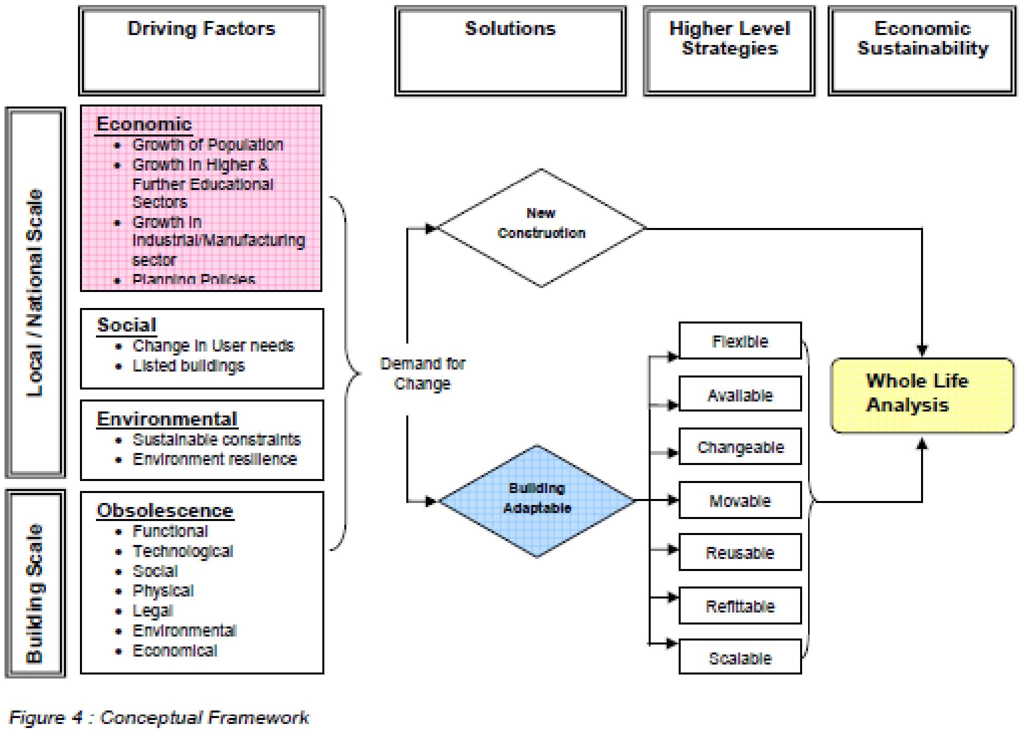

Figure 5. Conceptual Framework for Whole Life Analysis (Manewa et al., 2009)

Social Sustainability

Many of the above mentioned qualities that make adaptable, affordable housing more economically sustainable also help to create a more socially sustainable environment. For example, a family of recent immigrants into the Unites States would value a building much more if they had the power to adapt certain design aspects to fit their cultural practices. In affordable housing, this gives a sense of psychological ownership of space to people who may have never had that before. Edo argues that the poor physical condition of the architectural environment caused social exclusion of residents in public housing projects in the past. Conversely, well maintained, adaptable housing can contribute to social *inclusion* of residents. One example of adaptable architecture's role in maintaining this social cohesion is adaptation for the elderly. Support and building systems that can easily adapt to the changing needs of individuals as they grow old or less physically able allow them to age in place. This eliminates the need for tenants to move out, which is socially and economically disruptive. Conversely, well maintained, adaptable housing can contribute to social inclusion of residents.

Adaptability is perhaps more even more significant on the community scale of a housing project than the individual unit scale. Poor environmental conditions that Edo and many other scholars have critiqued prevented residents from building community networks. However, planning for adaptability at the building scale makes those networks an inherent part of the built environment, because residents are encouraged to work together with each other and with architects to design the building that they want to live in. This success is evident in the previously mentioned Gespleten Hendrik Noord complex in Amsterdam, where a healthy social bond has grown between residents as they seek to maintain their mutual commitment to their home (Kendall & Teicher, 2000). A combination of private and cooperative living like this is crucial to help tenants in what is ideally a transitional living situation. Truly transitional subsidized housing should reflect that quality by being adaptable.

Chapter IV. Designing Adaptable Affordable Housing—*Apto Ontario*

Figure 6. Apto Ontario North Aerial Perspective

The most important aspect to consider when designing for adaptability is different scales. This refers to both physical scales (room, residential unit, housing complex, neighborhood etc.) and scales of time (short term vs. long term). Affordable housing should be able to adapt across these different scales to maximize economic, environmental, and social sustainability. Adaptation is represented at these different scales to varying degrees in the design of *Apto Ontario* (Figure 6).

Building A

Figure 7. Building A Northwest Perspective

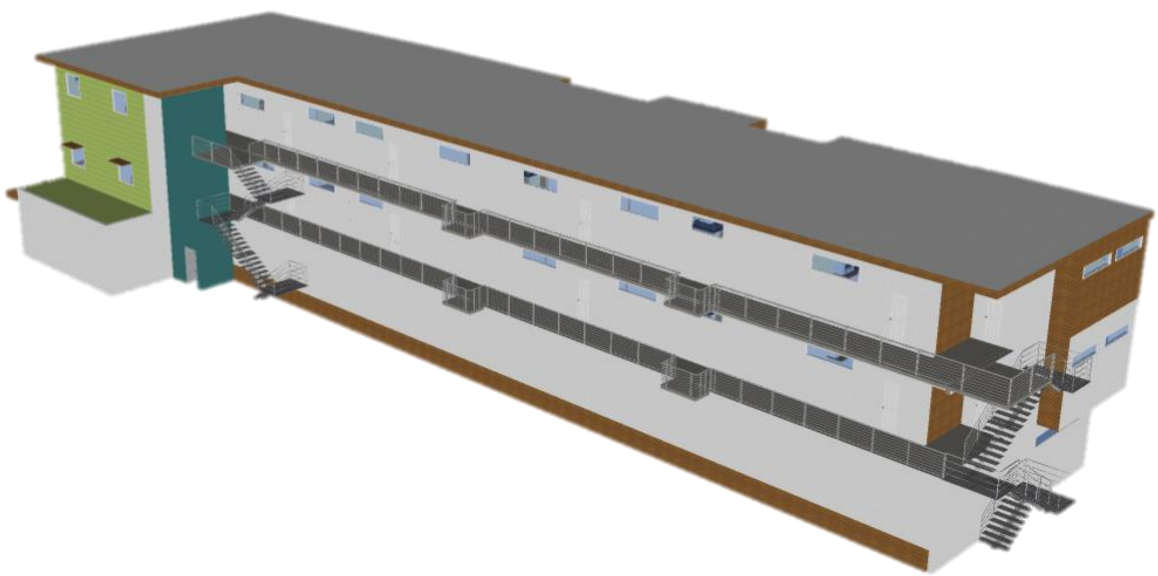

Figure 8. Building A Southeast Perspective

Figure 9. Building A West Section

Figure 10. Building A North Section

Figure 11. Building A Level 3 Floor Plan

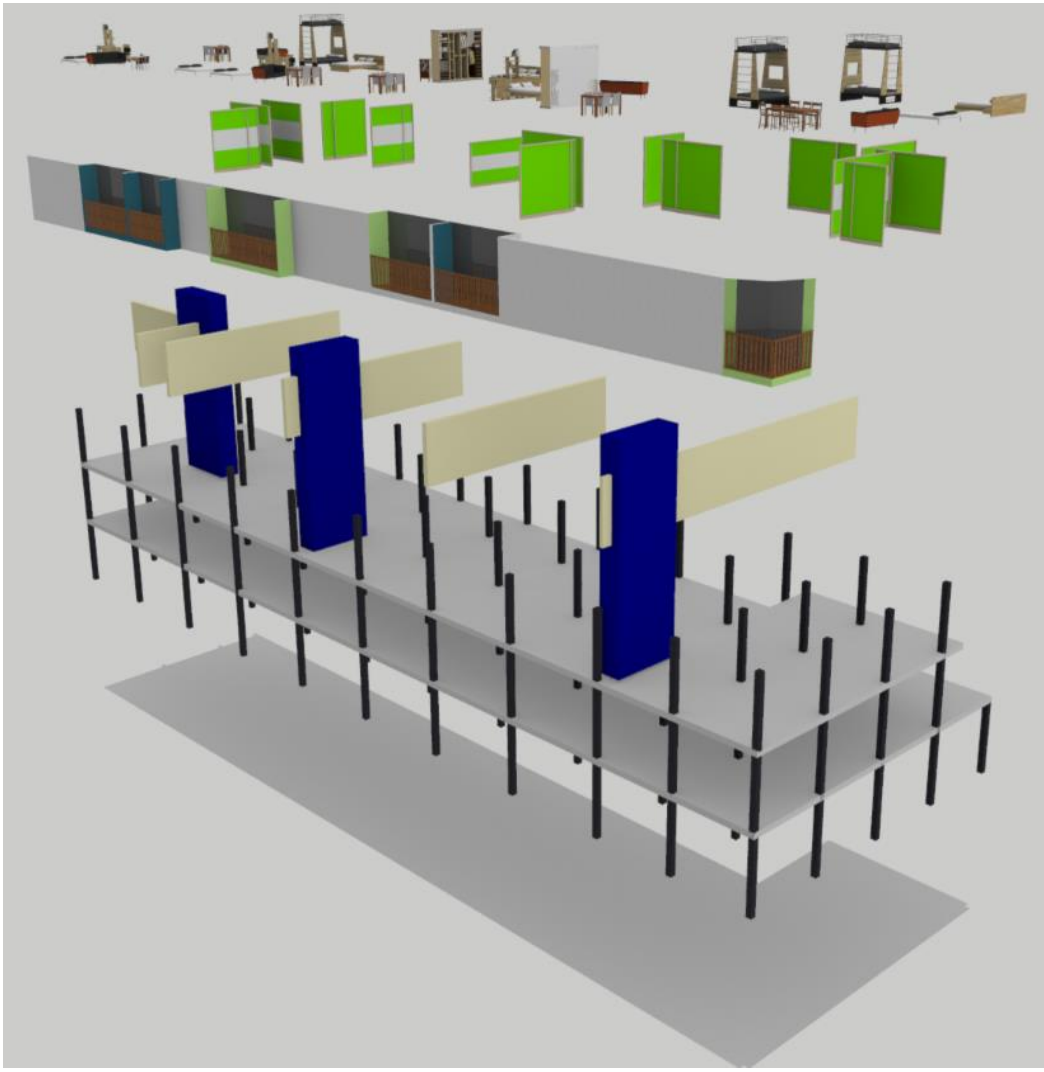

Figure 12. Building A Exploded Layers (From bottom to top: site, structure, system cores, unit partitions, façade, room partitions, furniture & amenities)

Building A is designed to adapt easily over shorter a shorter temporal scale and smaller spatial scale. The base structure, partitioned units, and interior infill of units are all designed in a modular coordinated system (Figure 12).This system separates the load bearing structure from the partitioned interior, so unit floor plans are more open to adaptability. Similarly, mechanical subsystems stem from vertical service cores that can be easily accessed for maintenance and long term retrofits. These mechanical subsystems are further coordinated into a grid within units which would allow for easy adaptation of floor plans. Adaptation of unit floor plan utilizing a system of wall panels is the most important component of Building A residences. Aside from kitchen and bathroom spaces, the remaining unit space is left as indeterminate space that the occupant can choose to fill according to their family, cultural, generational, etc. specifications. The units represented in the plan (Figure 11, above) include a single person studio with an office, a small 2 bedroom, a medium 2 bedroom with living room, a 1 bedroom with office space for 2 and living room, a 3 bedroom, and a 3 bedroom with living room. The purpose of this variety is to easily accommodate frequent changes of residents, while at the same time building a demographically diverse environment.

From an aesthetic, functionality, and sustainability perspective, panelized wall systems are much more advanced than when they were first utilized in the 1920's. An example of this is DIRTT—Doing It Right This Time—Environmental Solutions, a company that prefabricates customizable modular wall systems. An advanced system similar to this would be used to ensure that no functional qualities (i.e. sound insulation) are sacrificed for purposed of adaptability. *Apto Ontario* would store certain elements on site to be interchanged between units, but could offer further customization from the third party provider as well.

The design or Building A plans for adaptability of units as the composition of tenants change over its life span. However, the modularity of the building also allows for joining or dividing of units over time. Further, the roof was left flat to accommodate possible upward expansion or use as a garden. A much higher building currently would not fit into the existing framework of the historic downtown Ontario, but there may be a need to accommodate denser housing in the future. This is especially true due to its proximity to the new bus rapid transit line connecting the Inland Empire to the Los Angeles city center.

Building B

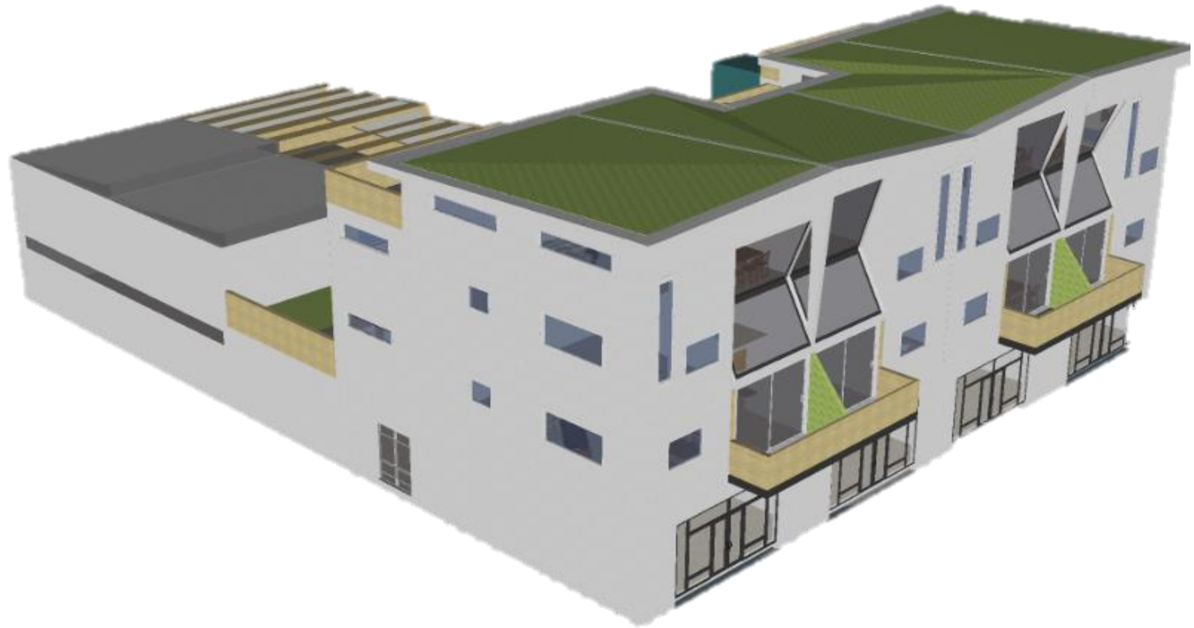

Figure 13. Building B Northeast Perspective

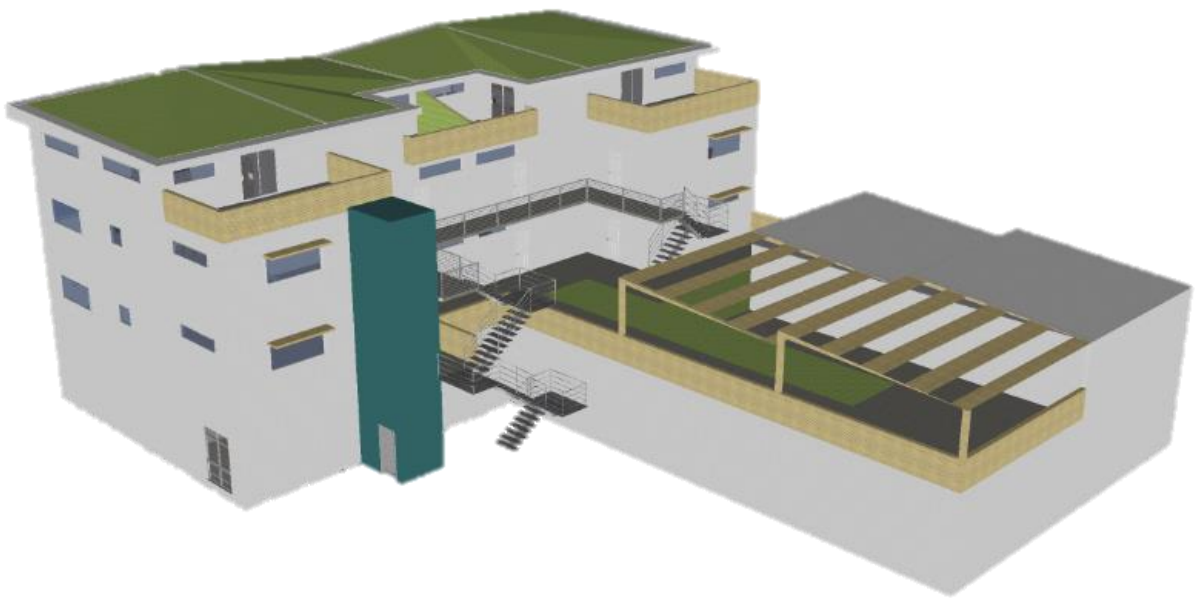

Figure 14. Building B Southwest Perspective

Figure 15. Building B North Section

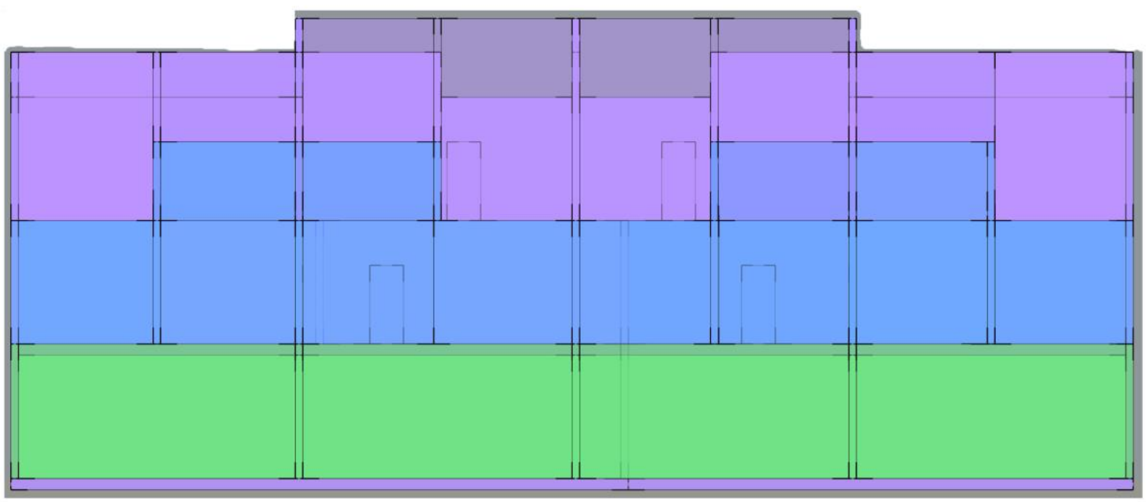

Figure 16. Building B North Section Showing Vertical Distribution (green = retail, blue= level 2 entry units, purple = level 3 entry units)

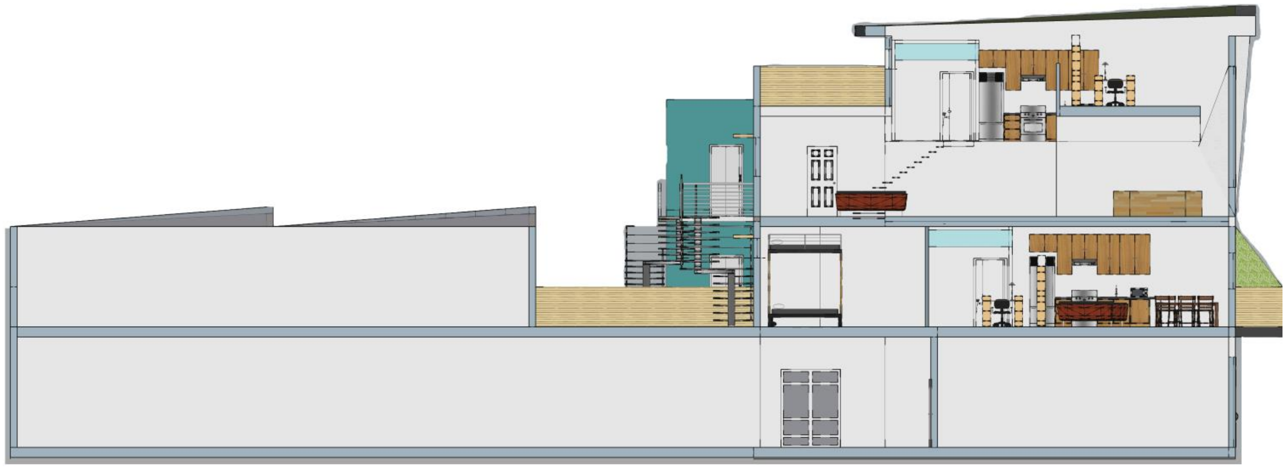

Figure 17. Building B East Section Showing Resident Amenity Space (left) and Lofted Residential Units (right)

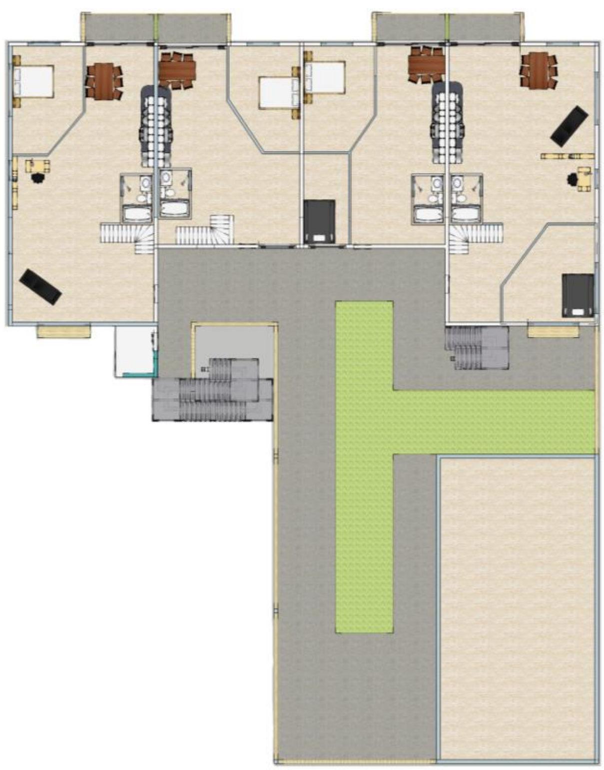

Figure 18. Building B Level 2 Floor Plan

(Entrance to Level 2 Units)

Figure 19. Building B Level 4 Floor Plan

(Lofted Section of Level 3 Units)

Building B is designed to accommodate adaptability at a slightly different scale. Instead of short term tenant to tenant adaptability, such as the design of Building A, Building B is designed to adapt to long term tenants. The building, similarly modular in structure, unit infill, and mechanical system coordination, contains units with high ceilings that can be adapted into lofts (Figures 15-19). This adaptation is meant for long term residents, because it would require additional initial investment and more intensive remodeling process than the panelized wall system in Building A. The structural necessities to expand into the loft space would already be in place, allowing for simple adaptation. The third floor apartments already have access to their roof top deck, which is designed as a precursor to the lofted space. Funding problems for this kind of tenant adaptation could be solved by making affordable units such as these for those seeking to buy, rent-to-own units, or tenants could possibly pay rent at a reduced rate to account for the additional investment made on the space (a strategy used by French social housing projects). Again, this scale of adaptability will attract a different type of tenant than Building A. Longer term residents are necessary to maintain a strong social bond and community commitment.

The concept of vertical expansion can also be applied down to the first level into a rented commercial space. The entire ground floor of the complex is designed to contain either commercial/retail space or space for communal resident services. However, the spaces directly under the Building B lofts will be rented at a subsidized rate to residents who have an entrepreneurial plan for the space. This space can be connected to the above units using space provided for a staircase. However, if residents do not want to utilize this additional space, the ground floor and the second floor can remain separate and the ground floor retail space will be rented at a fair market rate. Further, any portion of the ground floor space could be acquired for additional communal resident services if the tenants agreed upon an unserved need and developed a concrete plan.

Site and Surrounding Area

Much of the site that is not designated for residential space is left as indeterminate communal space. Some of this space would be designed (with resident participation) in the initial planning of the complex, while other areas may be left as raw space that can be built upon in the future. For example, in the initial design process, only the ground floor communal space might be built—containing a communal lounge, laundry room, and computer lab. The roof would remain a deck that could be built up in the future—if residents realize a need for a daycare, health center, or some other needed amenity (Figure 17).

Figure 20. Apto Ontario Site Plan (Building A, Building B, Community Garden, Picnic Area, and Playground)

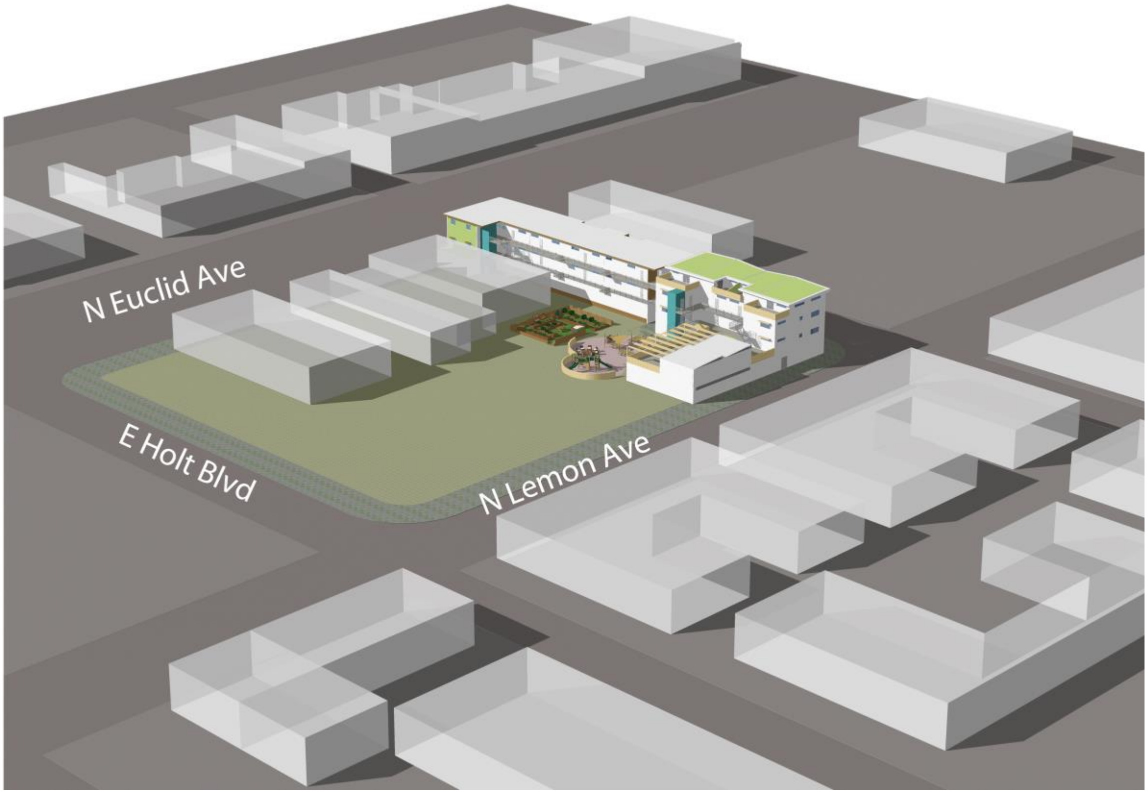

Figure 21. Location in Ontario, California (Intersection of New BRT Line)

Similarly, the overall site plan is left fairly open (Figures 20 and 21). In the initial design phase, these spaces contain a community garden, playground, other outdoor recreational space, and a courtyard. However, as discussed earlier, the site location is along a transportation corridor outside of a growing metropolitan area. This means that the urban density of Ontario's Historic Downtown may increase greatly within the next fifty years. Like the upward expansion possible in Building A, this portion of the site could also be built up to become a third building. The amenities currently at street level could be moved onto the rooftops of buildings, in order to accommodate a more dense urban fabric.

Chapter V. Conclusion

The *Apto Ontario* design focuses on adaptability of individual residential and commercial units, the buildings that contain those units, and the surrounding site. These features of adaptability function to create housing that is intrinsically affordable *for everyone involved*. This city of Ontario is planning a large scale redevelopment of the historic downtown area that includes higher density, mixed-use buildings. This plan and the development of the new BRT line put current low-income (area median income $22,500) residents at risk of being pushed out of the area, due to increased rents. *Apto Ontario* is a design that would bring in a diverse group of residents and define the historic downtown of Ontario as an adaptable and resilient place, not a place to be entirely flipped and gentrified. The product of this is a community that is not only economically and environmentally sustainable, but also serves a model for social sustainability.

Some elements of this design, such as movable partitions and lofts, may seem small and insignificant in the worldwide effort to create a sustainable built environment, but these small elements are absolutely necessary to foster happy and healthy individuals across all demographics. This goes back to the issue of scales. *Apto Ontario* is one example of an adaptable solution, but in reality all layers and systems that have been researched here must be part of an infrastructural system that is similarly adaptable. Infrastructural systems must be adaptable to changing urban ecologies—both social and environmental. At all scales, changes are uncertain, but that uncertainty increases greatly at the scale of regional infrastructure. The rapidly changing surrounding environment demonstrates how rigid infrastructural systems of the present are at risk of becoming obsolete. Further, as exemplified by the horrific public safety situations during recent natural disasters, this is also a terrible environmental justice problem. Adaptable interdependent systems are the solution for designing a resilient and sustainable built environment. However, the design and implementation of these systems requires government cooperation, action, and funding. This kind of support is easier to acquire on the scale of a single building project, such as the proposal described here— however, garnering support is inherently more difficult on larger scales. Adaptable design practices show promise for the creation of more environmentally and economically sustainable architecture and infrastructure. Further research is warranted to investigate how these practices can be integrated into present and future systems in order to overcome environmental and social injustice.

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