2

SMART LIVING

"The very basis for my business over the past decade has been to build safe, flexible, sustainable housing with whatever look, feel, and contents my customers want."

— Margaret Hunter-Chang, Housetex Corporation

Earlier this year, Millennium Productions, Inc., taped footage for a new virtual reality (VR) drama in Oswego, New York. The VR production was a period piece, set in 1988 in a suburban neighborhood. The production company did not have to alter the scene for exterior shots of the houses, except for removing lawn-care robots, replacing modern vehicles with period ones, and dubbing in telephone poles via studio enhancement of the images. The same could not be said for interior shots. Those required complete studio mock-ups of period homes.

Not every modern neighborhood can pass for a 1980s or 1990s setting. But because of enduring tastes for housing in traditional styles, and because 64% of all affluent-nation houses today were built last century, many communities differ little superficially from their predecessors. The widespread differences are internal and hidden and in how people communicate and travel among communities.

In World 1 countries, shelter has been transformed, though not always visibly, by three central forces:

- *Information technology* — making everything a candidate for mechatronic enhancement and leading to the growing integration of house systems and functions. A room that knows all who enter and what their preferences are, for example, was only a concept a generation ago. At the same time, information technology enables better design and redesign of homes and control and maintenance of home systems.

- *Environmentalism* — pressing for the transformation of the home from an energy and resource waster in the 1990s to an energy conserver or even producer (in the case of active solar energy), and a resource recycler today. Environmentalism reinforces the trend toward greater integration of house systems and functions.

- *Materials technology* — changing the structure, cost, texture, and capabilities of materials of construction and decor and providing the basis for closing the loop of materials use in the home as elsewhere, with recycling, reclamation, and remanufacture.

The home as a workplace, common today, was a new concept in 1990. Information technology has been foremost in making this transition possible, as it has been in changing recreation, shopping, health care, and other domestic activities. Large-format flat video screens, such as we now commonly have throughout the home, were unavailable before 2011.

Elsewhere in the world, particularly in the destitute and lower middle-income countries, housing is visibly different in external appearance from what existed 35 years ago. That is because of changes in the materials used in shelter and new shelter designs adopted by developing countries. Polymer concrete prefabricated modular housing units have proliferated in those countries, as is illustrated by a case study of housing in Cairo, Egypt.

HOUSE AND HOME IN WORLD 1 COUNTRIES

It is in the affluent societies that people benefit most from advances in technology. In housing, affluent societies have seen a 35-year evolution toward new forms and functions of shelter, enabled most of all by information technology. The resulting homes are safer, more comfortable, more energy efficient, more flexible, more environmentally sustainable, more educational, and more fun than they were a generation ago. Newly built homes get a full complement of advanced technologies. Older homes can be retrofitted with almost any technology.

Settlement patterns reflect a hybrid of the old and the new

Transportation and information technologies make new settlement patterns possible by blurring the boundaries of space and time for work life and leisure. Still, traditional patterns lie just beneath the surface of modern communities. Those old patterns, reflecting how people worked and played in the last century, can be seen in the way communities lie as satellites around old urban cores throughout the United States and Europe. Metropolitan areas are

still seen as city-centered. Infrastructures are still partly oriented to the old urban core-centered patterns of the last century.

A great change for North American life, mirrored somewhat in Europe and Asia, is the return of vitality to rural areas. Information technology and new transportation systems made this possible. The aesthetic and lifestyle appeal of rural areas have made them attractive. The share of the U.S. population that is nonmetropolitan continues to fall. However, the number of people living in rural areas began to rise again in the 2010s and is growing by 0.6% per year.

Housing stock is another instance of older patterns persisting. For example, the average lifetime of urban dwellings in the United States, which last century was 40 years, continues into the present generation. Lifetimes will get even longer with more durable construction and slowing population growth.

Environmental concerns drive much of housing change

Greenhouse warming has shaped public policy and private action in all of the advanced nations. Governments have acted on public concerns about pure water and air, and there has been a net improvement over the past generation in the quality of air and water. Solid and toxic waste issues led to a nearly universal commitment to recycling, reclamation, and remanufacturing of goods. Conservation of energy and materials is now solidly backed by legislation in World 1.

Environmental problems shape legislation and regulation on housing codes, energy use, and waste-management practices. They also shape change in building materials and design through their influence on cost and on consumer attitudes and values. The market for solar technologies illustrates the continuing demand for sustainable and renewable resource use. Today, 16% of U.S. homes have solar panels for some or all of their electrical energy needs.

Architecture and interior design are freed from technological constraint

Architecture and design respond to new technologies and materials and to cultural forces. Over the last 30 years, the most powerful driver of change in architecture has been information technology. Patterns of energy use, pressures for energy conservation, and the introduction of new materials into the design stream have also reshaped architecture's tool kit and design paradigm. In addition to reshaping the standard detached house, technology enables sharing systems and services in apartment style living, making that option increasingly attractive.

New materials, design practices, and information technologies free architects and engineers to design structures unfettered by many historic physical limitations. The use of glass as a structural material, for example, has led to more "invisible" superstructures in buildings and concomitant design changes.

Closely related to architecture are technologies of construction. Building technology has been greatly influenced by new materials used in construction, pressures for energy conservation, and the extensive application of computers and other information technologies at the construction site. The most dramatic effect in construction technology this century came from the substantial growth of manufactured housing — that is, more extensive preparation of larger modules in factories where quality control could be managed more effectively. Mobile robots generally assist with site preparation and assembly. Manufactured housing, making ever more extensive use of robots in the factory, has steadily modified designs and use of materials to take advantage of automation. Flexible manufacturing makes customization more cost effective for the consumer.

A CASE STUDY: The U. S. home - an integrated system

There is no typical U.S. home. Homes fall within a spectrum from traditional low tech to high tech, and range similarly in how much environmental technology is built into them. All U.S. homes are under the influence of a set of shaping forces, driving them to their roles in more careful management and integration of systems, environmental friendliness, and information intensity. The penetration of the latest technologies usually depends on the affluence of a household and on its attitudes toward and interests in technology. An exemplary U.S. home is depicted below. Similar technologies are available for attached houses and apartments.

A Traditional Design Modular House

Today's homes are information dense, compared with their predecessors in the 1990s. The typical household, for example, receives external information via the network for work, play, education, and household management 17 hours a day. On average, today's upscale home and car have a combined $40,000 worth of information technologies compared with $5,000 in 1990. The home has two centers of concentration of this technology — the home command center, governing home systems such as heating, ventilation, and air-conditioning (HVAC); security; and waste handling; and the home work-study center (HWSC), sometimes also called the home information center. Meanwhile, flat screen interfaces can be installed anywhere in the home. The information-dense house, manages the internal environment to satisfy divergent health and comfort needs.

The aging U.S. housing stock

The tenacity with which people hang on to old structures slows the uptake of advanced technologies in the United States. Housing sociologist Janet Jeffries identifies three reasons for the slowing turnover of the housing stock, 2005 to today:

- Aging society — With the median age of the population approaching 40, most U.S. homeowners today came of age and formed households early in this century.
- Traditionalism in the face of high tech — This more controversial supposition relates to human reactions to fast technological change. Jeffries says that people will accept advanced technologies more readily if they are packaged in familiar forms. Thus modern house designs are still sometimes reminiscent of the Cape Cod and ranch styles of late in the last century.

- Economics — Existing houses cost 85% of what new homes cost, making them more attractive despite the cost of retrofit technology.

In addition to the forces Jeffries identifies, the increasing ease of retrofitting and the extended lifetimes of structures and their contents avoid the need to replace structures as often. Analysts expect houses built today to last 60 to 80 years. Reconfigurable apartment complexes may last even longer, though they are rearranged and altered as often as every 10 years. Modularization of components makes alteration easier, obviating pressures to replace houses. Modular structures can also be relocated more easily than site-built houses.

Smart and smarter, integrated houses

Today's houses are smarter than their 1990s predecessors, few of which had any smart house technologies beyond programmable thermostats. Information technologies, coupled with sensors and actuators, make today's houses more fully integrated and automated.

There were two big factors in making today's houses smarter:

- The *de facto* integration and universal availability of digital, fiber optic networks, which matured only about a dozen years ago, and
- Mechatronics, making every appliance, device, and material a candidate for built-in microprocessors, sensors, or actuators.

The effects of embedding sensors and other devices are twofold:

- Devices, structures, and materials can act and react, independent of human instruction.
- Devices, structures, and materials gather information to inform central systems about their condition and use.

The net effect of this is that nearly anything in the home can become part of an integrated system. People interact by touch and voice with the system at friendly interfaces, including video screens, in most rooms and at their command centers.

Integrating the functions and systems of homes is advancing quickly, with nearly all new housing units built today having at least basic systems centrally integrated and controlled. The need to save energy and to align the household with environmental practices shape the use of information and control technologies.

Technologies at play versus technologies sitting on the drawing board

Most people have heard of Fully Automated Shelter Technology (FASTech). The automation standard and armamentarium of technologies is the descendent of smart-house standards first put forward in the late 1980s. Fully blown, a FASTech-equipped house would be the fully automated house dreamed of since sci-fi cartoons in the 1960s (*The Jetsons*).

In fact, many FASTech technologies are invented, developed, and ready to be marketed, but for cost and retrofit reasons are not finding markets in the United States. Except for a few FASTech demonstration homes and the homes of a few billionaires who insist on cutting-edge technology, the U.S. fully automated home has yet to be realized. Instead, U.S. homes combine advanced technology and automation with human labor. Robotic chefs still require some care and feeding by the user. It is far too expensive for most homeowners to have outdoor robots that remove recyclables and clean out gutters.

Integration is nearly universal in multifamily structures. Apartment, condominium, and cooperative housing complexes, as well as modern suburban developments of detached and semidetached housing have carefully managed systems including security, HVAC, wastewater, solid waste and recycling, and energy conservation. Factory construction of housing and modular housing units have made building in integration systems more cost-effective. In the most complete systems, greenspaces are also becoming integral parts.

Integration systems have been more difficult to retrofit into older housing. As a result, about 54% of U.S. housing units have incomplete integration systems, lacking either a command center or controls on the six main units of the smart house: HVAC, water, energy, solid waste, liquid waste, and security. Nevertheless, the home retrofit market for management technologies has brought tens of billions of dollars in revenues annually to the companies serving it.

Plugging into the communications network

With regulatory paths opened up since about 2005 and the standards jungles being cleared, all new building complexes and nearly all new homes have been fully wired for broadband. Yet even today, the costs of access and services keep people from using the capabilities that exist. As is typical, the technological capability is available, but developers and buyers cannot or will not afford it. The same cost problems have slowed the retrofit market.

Nevertheless, more people use more information services and networks from home than ever before. Thirty-five years ago, only 3% of the labor force worked off- site. Today, 40% work at least several hours a week off-site, often from home.

Telecommunications has meant that more people can participate in group activities without leaving home. Today's software and hardware make doing so even easier. The FolkNet software system, for example, helps users form groups who share common interests. Such systems make it easy to set up and track communications with a far-flung group, whether it be via televideo, computer messaging, or virtual conferencing.

2025

Energy use

Concern for energy costs has shown up in the materials used in home construction and in home design and management. The most widespread development has been smart windows, which respond to light and heat flux. The market for them has grown rapidly since around 2000 with an added boost from public/private conservation incentive programs.

The new helps preserve the old

Today's capability for tight control on interior home environments makes it possible to protect antiques, musical instruments, fine fabrics, heirlooms, and works of art. Humidity, light, temperature, and vibration control mechanisms can eliminate much of the damage caused over time to such family treasures. Security, meanwhile can be established not only for the whole home, but also for particular items such as antiques.

In homes with central command modules, all systems are coordinated for energy efficiency. Residents can assess their practices and monitor the outcomes of opening doors, windows, and skylights, as well as how they use their passive ventilation systems and smart windows. They can also establish preferences and let the house manage itself. EnergyMonitor systems, available since the 2010s, allow the home to automatically buy energy during low-use times when rates are lowest. This is especially attractive for charging electric vehicles and recharging heat and cooling storage systems.

Safety and security systems

An area where the smart home concept has moved rapidly is in community safety systems. Fire, flood, storm, and accident losses have been reduced to nearly half the rates of the 1990s, and insurance rates have dropped. This concept wasn't even around a few decades ago, although its seeds can be seen 40 years ago in burglar alarms linked to police stations. Since then, information technology has allowed the maturation of comprehensive monitoring and alert systems that encompass health, accident, crime, fire, and weather warnings. Condominium complexes and lifestyle communities led the deployment of community safety systems where the housing manufacturing industry has worked closely with developers, governments, and service providers to build integrated community-scale systems. This individualized, coordinated, community-scale approach has been the most effective way of deploying advanced technology while still allowing for diversity and flexibility in regulation, codes, and construction.

Safe home, healthy home

"Safe home, healthy home" is the American Home and Building Technology Association (AHBTA) motto. By 2011, the AHBTA had established standards, revised triennially, for home safety in materials and devices.

Overall, only 39% of U.S. homes are AHBTA-approved Safe Homes. AHBTA-approved homes have higher resale values. Among other successes, Safe Homes, with medical monitors and complete voice-actuated Safe Fixtures, have helped hundreds of thousands of elders maintain their independence.

Any individual home or workplace information equipment now is usually secured against tampering and theft. Traditionally, codes and key locks protected computers and other information consoles. The difficulty was in protecting information as it was being transmitted through the network. One universal information security retrofit device, for example, is Nab-A-Thief™. This device combines user-tracking technology with a thumbprint scan identity checker. The device can be installed on nearly any information device. Similar tracking and ID devices are widely used to secure appliances and structures.

Mixing outside and inside

Integration and control technologies would seem to create closed, artificial environments. In fact, they also allow a blending of the outdoors with the indoors, to almost any degree people want. Indoor greenspaces, invisible barriers to the outdoors, and home ecospaces are examples of how people manipulate the aesthetics of their indoor environments. A burgeoning hobby is the art of bringing ecospaces into balance and keeping them that way. Among the most popular things to do today is to create a tropical climate in a living area of the home for year-round enjoyment. At the same time, 18% of detached and semidetached homes have a vegetable garden or greenhouse.

Managing the home sustainably

Environmental sustainability is a central goal of home management. Federal and local regulation, as well as public attitudes about living sustainably where possible, have transformed two critical aspects of home life: energy use and waste handling.

Because much of the housing stock in the United States is 40 or more years old, retrofit systems are essential for converting houses to sustainable practices. The home environmental audit, now a standard practice countrywide, identifies where changes in construction, technology, and practices can make a home more environmentally friendly. Although people did energy audits starting in the 1990s, more careful systems models of homes and the

integration of environmental technologies with other systems make it possible to make much greater gains in energy and resource efficiency today. It is educational for family members to see an energy and resources flow model (in 3D and color) of their home as a dynamic system. They can have routine access to a model in the home televideo system.

Information technology and the modern home

All new houses and buildings are fully fibered for broadband communications. Technologies have long been available for retrofitting nearly any older home with broadband communications technologies and a complement of integration technologies. At a minimum, installers can give older homes full access to communications, information and image services, and two-way utility control.

The Eames Bed

Named for Charles Eames (1907-1978) who developed the concept, and patented in 2019, the Eames bed is a home medical device. Built into an ordinary bed, the $1,500 device monitors the occupant's health. Users can get a report each morning, or have all data or emergency signals sent to medical professionals automatically. For the bed's 89,000 users, heart attack deaths have dropped by 16% measured against people of similar health status who do not use the bed.

Monitoring technologies can go too far

Sometimes capabilities can lead to overuse or ill-conceived uses of technologies. One example was the EntryWatch system installed on a voluntary basis by 16 electrical utilities in the United States in the 2010s. The systems were a marketing failure for every one of the utility companies. These systems incorporated devices that measured heat loss or gain when a person opened a door or window. Digital readouts at the door or window announced the exact, to the penny cost of each opening and closing.

According to surveys done on homes equipped with the devices, people began to exhibit "prisoner behavior." Some restricted their trips outdoors. Others covered the readouts with black tape, preferring not to know how much they were spending. On the other hand, others praised the system for helping them teach spouses and children not to waste energy.

Sensing and reacting

The advent of multisensor packages for home control, safety, and security is at the heart of home integration. In 2005, nearly all commercially available home sensors did only one thing, such as burglarproofing or fire safety. By 2015, the sensor market took off with affordable packages that monitored indoor air pollution, health conditions, and aesthetics such as noise and light. Today, embedded sensor arrays are standard in structural members and fin-

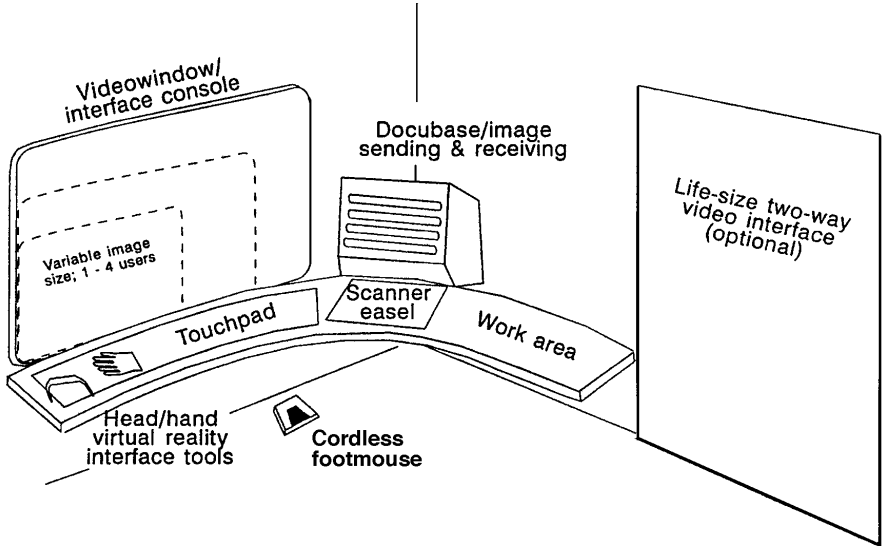
ishes. The latest sensor arrays now in development can track over 200 environmental compounds and conditions; and automatically control appropriate filters, scrubbers, and ventilators; and monitor structural members for stress.

The home work-study center

Part of any affluent and most middle-class homes is the home work-study center (HWSC). A HWSC combines the information technology needs of the worker, the student, and the leisure user in one integrated computing and telecommunications package. The ergonomics of the HWSC are nearly as critical as the information technologies included, and designers continually modify their designs for optimal use by children, adults, the aged, and for mixed purposes. A typical HWSC is depicted schematically below.

The Zenith Model HIC2900 — Family Interface Center

The HWSC depicted below is descended from a version first designed and built by IKEA in alliance with Zenith in 2003. The two companies continue to sell modular systems to 23 million households worldwide each year.



Work life patterns depend on the home as a workplace

Work life shapes life at home. In 1995, about 3.5% of the workforce were involved in some kind of off-site or distributed work. By 2005 that rose to 20%. Today it is 40%. In that pattern of off-site work, the majority of off-site workers still appear at a traditional central workplace once or twice each week. Another large group of workers perform their work at home or at local

satellite centers within two miles of their residences. The most striking development is the number of professional, managerial, clerical, and support functions carried on at home. Over the past generation there has been a widespread development of small professional services businesses, involving one to three people, and dependent on a handful customers or clients. This pattern evolved in the late 1990s and the first decade of this century. Over 66% of these ventures, by a recent estimate, use the proprietor's home part or all of the time. This powerful trend led to changes in the use of space in the home and to the design of new homes and home workplace technologies.

The materials revolution in house and home

Traditional and advanced materials shape home construction, furnishing, and finishing. The box below shows the outcome of shifts in materials use in a typical house, from 1990 to 2025. Note that the average home size has shrunk from 158 to 139 square meters.

The Changing Materials Makeup of a U.S. House

Typical 1990 158 m^2 home	
Amount of material	% of total cost
23 m^3 lumber	18%
42 m^3 concrete	14%
451 m^2 sheathing (metal >>> wood)	10%
208 liters paint	2%
136 kg nails	1%
12 windows	4%
604 m^2 gypsum wallboard	7%
232 m^2 siding (alum. > wood > brick)	8%
232 m^2 insulation	2%
185 m^2 asphalt shingles	2%
27 m HVAC ducting	2%
137 m plumbing pipe (copper >plastic)	2%
229 m copper wire	<1%
fixtures/appliances	22%
other materials	5%

Typical 2025 139 m^2 home	
Amount of material	% of total cost
22 m^3 lumber	17%
18 m^3 duracrete	12%
502 m^2 sheathing/sealer (composite >metal)	12%
200 liters coatings	2%
127 kg nails or adhesive	<1%
15 windows	6%
516 m^2 wall panel (gypsum > composite)	10%
195 m^2 siding (alum/brick/wood >poly)	9%
185 m^2 durashingle	2%
30 m CEC ducting	1%
143 m plumbing pipe (composite > copper)	1%
305 m wire (copper ≈ fiberoptic)	1%
fixtures/appliances	20%
other materials	7%

The lingering importance of traditional materials

Traditional materials, sometimes in new forms, coexist with advanced materials in home construction. For example, wood is still a favored material for interior finishes. Usually it is genetically engineered plantation wood, made rot resistant, fireproof, and given exotic grain patterns and colors. For eleven

years, extrudable plasticized wood has been on the market for custom and standard finishes, furnishings, and interior decor.

The biggest developments have been the many new biochemical treatments for wood. These have extended the lifetime of the home and reduced the need for maintenance and repair, and they have made lumber and construction waste safe and environmentally benign when burned or disposed of. Lumber from genetically engineered plantation trees is proving its superiority in resistance to rot, pests, stress, and water. Its longevity remains to be seen.

Framing and structural members, on the other hand, are most often made of extruded polymers, metals, and composites, in the case of roof trusses and joists. Because 86% of housing units are factory built in modules, designers choose materials that are readily manipulated by automation. Extrudable, moldable, and formable materials make structures more economical and flexible.

Mass customization with coextrusion

Mass-produced housing can be customized through surface finish coextrusion where a color/texture finish is applied in the factory to standard interior or exterior sheathing. First used to build standard model varieties of housing modules, increasingly coextrusion and other automated mass-customization mechanisms are used to let the buyer specify combinations of finishes and options at the sales console.

Getting the house you want

More people today are customizing their new homes in the factory. Among the tools making this possible are architectural design systems. A premier version of these is the latest system from EXPERTS, Inc., described below.

A top-of-the-line automated design system

EXPERTS, Inc., has just announced the franchising of its new architectural design system intended to be used by private citizens, although it is also applicable to the professional architect, in laying out and practicing alternative designs and patterns for homes and apartments. The machines will first be made available through franchised mall shops operated by Space Consultants, Inc., which has 243 shops in shopping malls throughout the United States.

EXPERTS claims that even a nine-year-old can effectively operate the system. It purports to combine information from the work style and psychological inventory to augment and shape the users' judgments about the design, layout, furnishings, and decor of house and home. It provides alternatives within that framework as a function of income, ethnic background, and 13 other cultural and social variables. The system, operating through a Sony MARK6 Virtual Reality Suit allows the operator to walk through and visually and kinesthetically experience alternative designs. One purported weakness is that they have not yet satisfactorily perfected the experience of flopping into furniture.

EXPERTS is seeking a commercial alliance with BigW, the totally customized, wood-plastic-based home fabricator.

Can you build one yourself?

Although home assembly and construction experts recommend against build-it-yourself houses, this practice appeals to a certain sector of the market, and as many as 20,000 modular houses are assembled by hand each year. About 12,000 traditional, site-built houses are built each year. Fabrihomes, Inc., and other factory housing companies, recognizing the small but significant market for do-it-yourself (DIY) housing, sell kits to the DIY market. Most difficult and problematic, however, is the use of adhesives and sealants applied on-site. Most kits include a video that offers special instruction on the more difficult techniques.

Automated construction sweeps the housing market

Factory construction brought automation to housing starting about 25 years ago. It was not until the 2010s that outdoor robotics made widespread use of construction robots possible. Their earliest uses were in straight-line or laser-guided functions such as grading and paving. By 2008, robotic excavators were in use to dig foundations. Remote operators were then and are generally still on hand to guide the systems around problems. Today, machines such as the Caterpillar Model X34 Robostruction and assembly trailer, described below, make site assembly cheaper and faster.

Caterpillar Model X34 Robostruction and assembly trailer

This device's 2025 model comes with a robo-operated, laser-guided ground preparer. It is usable in all conventional applications. It includes automated assembly capabilities usable with manufactured structures involving metals and all construction-grade plastics for buildings up to three stories high.

Home life in the smart, integrated home

The result of 35 years of smart-house evolution is safer, more efficient, and more pleasant homes. People are free to do more work and to play more, because their houses can manage themselves. That is the ideal. In reality, every home owner has different practices and experiences with automation and integration, and housework and management loads vary.

Getting food on the table — finally getting easier

Only 10 years ago, people still engaged in the hassles of meal preparation or were regular subscribers to meal delivery services. In quick succession, there was the development of the tunable microwave (2016), robot chef (2019), and automated pantry (2020). Today, about 80% of homes have the latest microwave technology. Only 22% have robotic chefs and automated pantries, which are usually used together.

Dodging maintenance chores

U.S. households are locked in an endless struggle to reduce and remove chores. Technophiles make a hobby of automating household chores and programming appliances and domestic robots to do more. Many spend more time tinkering with their systems than they would doing the chores the old fashioned way — using dumb tools and appliances. New homes built or reconfigured since 2009 have a video and data record of their histories. These records are effectively owner's manuals for homeowners.

Attitudes about household chores

The 87th Annual Gallup Poll of American Values (2024) looked at U.S. household chores and people's attitudes about them. Leading the list of the most hateful chores were doing the dishes, servicing the building diagnostics system, cleaning the HVAC precipitators, and reprogramming the home security to accommodate house guests. Doing the dishes is no surprise. That was also high on the list back in 1990. The home automation industry has been promising foolproof automated dish handling since the early 2000s.

Other 1990s chores that no longer concern Americans are vacuuming, ironing clothes, and taking out the garbage. How many kids understand what "taking out the garbage" is?

The same Gallup Poll looked at people's favorite home maintenance chores. For the fifth straight year, the favorites were testing the health monitoring module and View Vision shopping.

Managing sleep, waking, and circadian rhythms

Even circadian-rhythm-management can be automated. For example, Hitachi has the Waking and Sleeping Health Center, adaptable to most homes, that provides induced sleep, round-the-clock monitoring of vital signs and health, stimuli for resting, thinking, or physical activity. It can be used simultaneously by up to three people, if they are all within 40 feet of the unit. These are still expensive technologies. The average American that tries to manage sleeping and waking still uses melatonin treatments, caffeine, and bedroom environmental controls to regulate perceived noise levels, light, and temperature.

The home replaces clinics and hospitals as the key health maintenance center

With the growing emphasis on self-care in the United States, the home has become the center of health care for most people. Routine health and medical monitoring is done daily through health-monitoring systems in the home. Where needed, external information capabilities and human medical advice are available through televideo links.

HOUSE AND HOME IN WORLD 2 COUNTRIES

The typical middle-income country, like a paler version of World 1, has a mix of the old and new in housing. Income levels usually dictate the uptake of advanced technologies for households. New housing units nearly always make use of advanced building materials, like those used in World 1.

A runaway bestseller across World 2 is home security. These are not the built-in, integrated systems of the affluent home; they are add-on devices that detect entry, tampering, and unwanted trespass. Rising violent crime and theft in the developing economies has made security devices an annual $13.2 billion market.

There is much less of a market for retrofit information technologies and automation. The table below summarizes the housing situation in World 2 countries.

House and Home in World 2 Countries

Housing stock	In most countries, as much as 75% of the housing stock was built before 2015.
Settlement patterns	Continuing metropolitanization means more people live within 40 kilometers of the center of a major city than ever before. Most urban people live in multifamily structures, whereas rural people live in detached houses.
Design and construction	Designs are traditional, as are most construction practices. Innovative design comes with prefabricated housing, which is growing as a share of new housing units.
Materials use	Traditional materials, such as wood, stone, mud, adobe, concrete, and brick, are used along with new materials, which include extruded structural polymers and sheeting.
Energy use	The widespread adoption of insulation practices has reduced energy use for home heating and cooling, but net energy use has increased because of the increase in use of electrical appliances and central HVAC.
Environmental technologies	Reduced emissions furnaces and hearths are growing in prevalence.
Waste management	Recycling and waste-handling systems are taking off, starting with demonstration projects in the 2010s.
Work life at home	Most workers still work outside the home. However, many ply a home-based trade, run a shop at home, or provide a service from home. Few professionals and nonindustrial workers as yet work at home.

Home life and leisure	Advanced video technologies and home computers are restricted to the more affluent households of the middle-income countries. Poorer people may have access to information technologies for education and leisure at community centers.
Information technology	Home computers are still rare. Radio, cable, and broadcast television provide most connections to the outside world of information.
Safety and security	Home security systems are among the first homeowner investments. Sensing systems and perimeter penetration detectors are used by most households that can afford them.
Food preparation and consumption	Traditional food preparation practices, including hearth, stove, and microwave cooking continue to be most common. More food preparation work is done by hand than in the affluent countries, though packaged convenience foods have grown to be an annual $600 billion market worldwide.

HOUSE AND HOME IN WORLD 3 COUNTRIES

In the world's destitute countries, housing is traditionally an ad hoc technology. People work with the limited resources at hand to build and furnish their houses. By some estimates, over a billion people in the world live in hand-built shacks, typically made of waste materials found in municipal landfills. The conditions in these communities are unhealthy and desperate, despite decades of international aid efforts to improve them. Those efforts continue, as new planned communities for the poor take shape.

The big change is prefabricated housing. Modular prefabricated housing units are now a staple of development. The practice began with experiments last century, and took off in the beginning of this century. The table below outlines a series of such schemes.

A Comparison of Housing Schemes in Developing Countries 2000 - 2025

Years	Model	Locations	Material	Method	5	6	7	8
2017	Concept-7	Al-Uqşur, Egypt	Reinforced polymer composite	Cast/layup	P	H	Y	$990
2015	Earthtech	Mexico City, Laredo	Rammed earth	Earth compacted in reusable frame	S	H	N	$210
2023	Sakura Model-D	Port Moresby, Papua New Guinea	Fiberglass	Spun/cast	P	L	N	$550
2015-2019	Casa Fabrica	Lima, Belo Horizonte, São Paulo	Thermally compressed plastic	Panels and frame members	S/P	H	N	$423
1998-2014	Jambo Nairobi	Nairobi, Kinshasa	Advanced concrete	Cast	P	M	N	$352
1997-2003	Desai Complex	Bangalore, Colombo	Polymer concrete	Cast	P	M	Y	$809

Key: Column 5 — P=prefabricated, S=site fabricated
Column 6 — L, M, and H for low, medium, or high alterability (by the owner)
Column 7 — Y for stackable or N for not stackable
Column 8 — Cost to dwelling resident at time of project in 2025 dollars

In the next section, a case study set in Egypt depicts shelter in a typical World 3 society.

A CASE STUDY: Shelter in Egypt — building communities for the poorest

Egypt is a country with a mix of middle-income people and destitute people. The country's 98 million people have a *per capita* annual income of $2,425. That average masks the widening gap between rich and poor in Egypt. People in the poor communities average half that amount.

About 22 million of Egypt's people are destitute, living in shelters built of waste and surplus materials, often in squatter settlements surrounding large cities. Several million such people in Cairo, for example, are Zarrabs — people who make their livings scavenging garbage from the city's waste heaps. By one recent estimate 170,000 Egyptians are homeless in Cairo alone.

This case study examines house and home in Cairo, Egypt, with a special emphasis on its shanty towns, which are typical of housing in World 3.

Shelter and living conditions in Cairo, Egypt

Egypt's destitute live in violent, unsanitary conditions. Although outright hunger is rare, malnutrition is widespread, affecting at least half of all children in squatter communities and shanty towns. People suffer from preventable infectious diseases, due to poor sanitation systems and practices.

Most dwellings are of materials scavenged from waste dumps, or from traditional materials such as stone, mud brick, and concrete. Recent additions to this, sponsored by the Government Housing Ministry, is the use of recycled plastic materials, fiber-strengthened, and fireproofed. Rising fast in squatter communities around Egypt are new prefabricated housing complexes. These offer the destitute a path to better, more healthful lives.

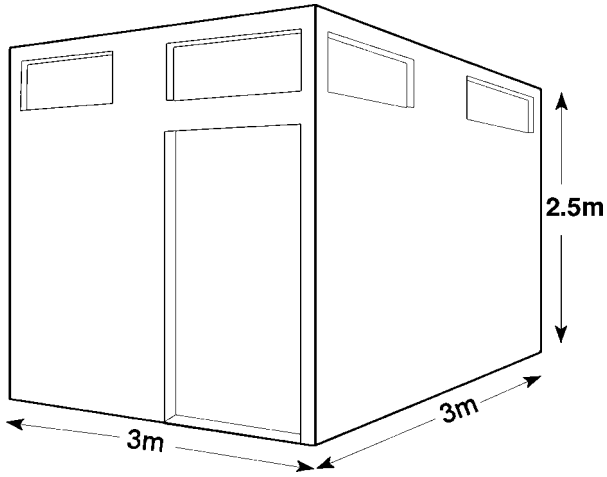
Sprawling poor communities surround core cities in Egypt. Most people live in single-story shacks, 12% in high- or low-rise apartment buildings. The communities are crisscrossed by foot and bicycle paths. Buses and trucks, mostly privately run, offer cheap transportation around cities.

A typical prefabricated housing complex

The Al-Uqşur Project, begun in 2017, is a successful example of a planned community for destitute urban peoples. Al-Uqşur is a sprawling squatter settlement southeast of Cairo. The project involves selling families basic housing modules (the Concept-7 Dwelling Module) developed for Al-Uqşur and subsidized, costing families the equivalent of nine month's income. Each family could install and improve a base structure through sweat equity, perhaps buying add-on units later. Already about 2,300 families live in Concept-7 houses.

The Concept-7 Module, depicted below, is of reinforced polymer composite prepared by a combination casting/layup process. The modules may be made partly of recycled polymers. The Concept-7 module is configured according to traditional designs found in Cairo dwellings. The module conforms to Cairo's building codes and standards. The units are readily joined side by side. The ideal home is 2 to 4 units, depending on family size and home-enterprise work. Al-Uqşur residents continue to modify their units by adding lean-to structures and other rooms using found materials such as metal sheeting and scrap lumber.

Schematic of Concept-7 Module



Work life in and out of the home

The home is typically a workplace for the poor of Egypt. In urban areas, 28% of dwellings have workshops in them. The work done ranges from fabrication of shoes, cooking utensils, and other handicrafts, to appliance repair, tailoring, and food preparation. A third of residents work nearby in workshops, stores, and enterprises in other people's homes and yards. Another third work elsewhere in the community. Most people tend gardens, often on their roofs, as a sideline.

Waste, water, and environmental management systems

Largely based on international assistance and central government action, urban Egypt has begun to conquer its waste, water, and other sanitation problems. The secret to its emerging success has been to design systems that depend little on compliance with regulations by individuals. For example, people would not comply with rules about keeping sewage out of storm sewers, so the government decided to separate the two centrally using membrane technology.

Recycling, on the other hand, invented itself in Egypt. The Zarrab scavengers found economic incentives to collect and sort waste and to sell it to recyclers and remanufacturers. Thus, widespread recycling and reclamation took off in Egypt before they did in World 1.

Sewage treatment is decentralized in Cairo, and Al-Uqşur has its own microbial treatment system. The effluent is made usable for fertilizing home gardens and is given free to Al-Uqşur residents. Some is sold to the Upper Nile Farm Cooperative.

Energy remains a low technology at Al-Uqşur. The worldwide warming trend of nearly 1.5°C so far this century has added to the discomfort during Cairo's summers.

- Most homes have a solar cooker for the yard or rooftop; some have solar water heaters.
- Temperatures rarely drop below 9°C in winter, so home heating is not a problem. Some homes have Goldstar photovoltaic air conditioners. The units cost four months' wages. Other residents use electric fans.
- A program of tree planting in the community has served well for providing shade. The new date palm variety *Arecacea nishidae* survives in urban conditions on much less water and provides additional food for residents, from its annual date crop.

Home life and leisure are shaped by poverty

The average poor Cairo household has electricity, typically powering a light or two, a television, a radio, and perhaps a small refrigerator. Hundreds of thousands use portable photovoltaic panels for their electricity. About 22% in the Cairo area also have cellular telephones. Despite their poverty, the poor of urban areas in Egypt typically have community centers, cafés, educational centers, and mosques where they can have access to things they are too poor to have at home, such as video technology, air-conditioning, and health diagnostic equipment.

Rooftop gardening mitigates poverty for most households. Gardens are a highly promoted option for urban Egyptians. The Concept-7 structure used at Al-Uqşur, for example, can sustain an intensively worked, containerized roof garden. About half of Cairo's residents have vegetable gardens. Making garden soil lighter has enabled roof gardening for many. Inexpensive, lightweight synthetic soils made of waste polystyrene foam are a stock item at dry goods stores in Cairo. Genetically altered crop plants such as the pygmy vegetable varieties are successful rooftop crops.

About a third of poor Egyptian households have 0.4 cubic meter sulfur dioxide refrigerators from China. Fresh food is important as these refrigerators have limited capacity. These refrigerators helped solve the need for alternatives after the international agreement on CFC elimination by 2013.

Critical Developments 1990-2025

Year	Development	Effect
1998	Environmental Audit Certification Act passed (United States)	Made home energy and environmental auditing respectable and reliable and led to the growth in that service in the United States.
1998	Sustainability principles become part of school curricula worldwide	Beginnings of the movement to sustainability, especially influential in the home through schoolchildren
2002	Selling Sustainability campaign (United States)	Heightened awareness of how people can save energy and resources at home
2002	U.S. Energy Transition Act passed; massive conservation campaign	Helped inspire manufacturers and builders to implement more conservation technologies
2007	Full-fledged home command/integration systems become commercially available	Beginning of the information technology revolution in home management still underway today
2008	The nonmetropolitan United States population resumes growth	Reflect the growing ability of people to use information technologies for work and leisure, making central location less necessary
2009	EnergyMonitor systems come on the market	Allow households to make more energy consumption decisions and control energy use more effectively
2011	International Agreement on Standards in Construction	Developed standard measures of performance and capability for materials, including their energy efficiency and insulative capacity
2013	Recycling and Reclamation Act (United States)	Regularized and extended recycling/reclamation practices, including those done at home
2014	Factory manufactured homes surpass site-built homes in housing starts annually	Led to the recognition of efficiencies and economies to be had in factory building, and the greater flexibility and customization options available to the buyer

Unrealized Hopes and Fears

Event	Potential Effects
Extensive turnover of the housing stock built in the 1900s	Most houses could be built with a full complement of command and integration technologies, obviating the need for partial-solution retrofitting
A rash of accidents, including fatalities, caused by home automation technologies	Could slow or destroy the market for home automation technologies and smart-house systems
Widely available cheap energy	Remove economic incentives for home energy conservation, including materials use and control technologies
Cheap, renewable, easily disposed of building materials	Little development of recycling, reclamation, and remanufacturing practices, faster turnover of housing stock
Extensive ozone destruction and consequent high rates of ultraviolet solar radiation	Ultraviolet light would lead to surface damage. This or some other large-scale environmental threat could make necessary complex protective systems for houses and other structures and for the people in them