A Comprehensive Policy Brief for

Sustainable Housing

ENST Capstone Class Fall 2010
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Executive Summary

In the fall of 2010 a Capstone team within the Institute for the Environment at the University of North Carolina set about to try and answer the question: **What is a sustainable home?** The team decided to produce a policy brief that could present the current problems that make creating a sustainable home difficult, and then provide policy recommendations that could make this process easier. In the following sections of this brief, the rhetoric of the “three Es” — economy, environment and equity — will be used as a framework. The environment section explains issues dealing with energy efficiency, green materials, and water efficiency; the economy section identifies ways to educate about loans and grants and cost-saving measures; the equity section discusses accessibility and livability for everyone. While these sections overlap and interconnect, it was a shared feeling amongst the group that creating some kind of categorization was necessary to manage this overall broad inquiry.

The brief begins by defining what we refer to as “sustainable housing.” It is difficult to find a consistent definition of sustainable housing in professional work, but it is clear that the “three Es” framework is a great way to break up this topic into more manageable components. In each category, the importance of promoting sustainable housing and the current state of policy are presented; these are followed by a discussion of proposed policy changes and other general recommendations. It is important to note that, due to limited time and space, the following measures and suggestions are most certainly not complete. There are multitudes of creative and important ways to promote sustainability, in the full sense of the term, in our housing communities. We have high hopes, however, that the following information will serve as a useful starting point in addressing this crucial and potentially transformative issue.
The Problem Defined

“What’s the use of a fine house if you haven’t got a tolerable planet to put it on?”

Henry David Thoreau

Thoreau’s question is challenging. Yet the goal of this brief is to show that, in order to address the implications of Thoreau’s important question, we need a fuller and more holistic understanding of the question itself. We must ask not only what is the use of a fine house without a tolerable planet to put it on, but also, what is the use of a tolerable planet without a fine house? Also, how can we efficiently and equitably create a tolerable planet populated with fine houses and, by extension, strong and healthy communities? We contend that the answer is found in recognizing the inherent interconnectivity of the three E’s.

The most commonly referenced statistic in assessing the sustainability of US consumption patterns is that Americans make up 4% of the total population yet consume 25% of the world’s fossil fuels.¹ Within the US, residences account for 38% of national carbon emissions; thus, changing unsustainable household consumption patterns can potentially make a huge impact.² By promoting environmental values, we create affordable housing. By creating affordable housing, we promote a just and equitable home, community, and society. The three Es—economy, environment and equity—are mutually reinforcing. Together, they form the building blocks of our model of true, holistic sustainable housing.

ECONOMY

Importance of the Problem

The US has made a commitment to affordable and equitable housing. The “30% rule of thumb”—at most 30% of a family’s income should be spent on housing—was first codified into policy during the Great Depression. Since then, a complex history of affordable housing policy has developed, involving subsidization, public housing, sliding scales, housing choice vouchers, low-income housing tax credits and rental housing assistance programs, to name a few.\(^1\) Research has indicated that a broad rule of thumb is insufficient for capturing the complexity and nuance of providing affordable housing.\(^2\)

We believe that the best and most efficient way of providing affordable housing is through holistic, inclusive sustainable housing. We can make housing economical and equitable by making it environmentally responsible. In the following two subsections, we look at the examples of energy-efficient appliances and of the economic payoffs of photovoltaic technology to illustrate how affordable housing can result from sustainable housing.

Current and Recommended Policy

Energy-Efficient Appliances

The compact fluorescent (CFL) light bulb has become a symbol of energy efficiency, and a small but effective step towards creating a more sustainable home. Energy efficiency typically is defined as the energy services (e.g., lighting, heating) per unit of energy output, but it is also important to note the cost savings that can result from energy efficiency. Improving demand-side energy efficiency is an important strategy in creating more sustainable homes. The major problem with this is the up-front consumer investment cost for most energy-efficient appliances. The initial cost is typically 10% or more higher then the standard appliance, which can be a huge barrier for the low-income population. The trade-off of higher initial costs—the difference

between the purchase and installation cost of a relatively energy-efficient appliance and the cost of the standard appliance—is the expected lower future energy costs. The expected savings involve projecting the cost of energy, the amount of energy used by the appliance, and the estimated life span of the appliance, and discounting for future inflation.

Currently there are a number of different incentives and policies that support greener appliances in homes. The Federal Weatherization Assistance Program, managed through the Department of Energy, enables low-income families to reduce their energy bills by making their homes more energy-efficient. Many counties and utility companies in North Carolina have utility loan programs, which provide low-interest loans to residents to improve the energy efficiency of their homes (see Appendix A, table 1). These improvements include; installing storm windows, weather stripping, insulation, attic ventilation fans, and energy-efficient water heaters. The interest rate ranges from 6 to 7.5% over a 60-month period. Other policies offer utility rate discounts; examples include utility companies such as Duke Power, which awards homeowners who live in Energy Star homes with a 5.4% discount on each kWh after the first 350 kWh per month (see Appendix A, section 1.a and 1.b).

Introducing new state policy will help increase energy-efficiency investments in the residential sector. One example is policy that creates initiatives that educate consumers on the importance of conservation along with increased energy efficiency, which induces energy efficiency by providing information about potential energy savings. Examples of information programs include the Energy Star label, home energy ratings and other feedback for consumers about their energy consumption.

**The Economics of Photovoltaic Technology**

As the US works to wean itself off of domestic energy production from fossil fuels, the American consumer has multiple options, one of these being the installation of solar panels—photovoltaic modules—on one’s home for residential energy consumption. The benefits of installing a residential photovoltaic module are that both household energy bills and greenhouse gas emissions are drastically reduced. Although it would be ideal for every residential home to convert to photovoltaic modules, there are multiple barriers; the largest barrier is the financial aspect, specifically the upfront costs (“Bumps in the Road”). Right now, the upfront costs of
Photovoltaic (PV) system can be around $35,000 before any rebates or tax credit subsidies.\(^1\) Although a PV system is a major investment that will pay off in the future, this is an unaffordable upfront cost for most families in North Carolina, thus making it an equity concern. Therefore, one thing that government can do to overcome this major barrier and thus incentivize the use of PV systems would be to increase the state tax credit for PV systems.

Right now, 55% of North Carolina’s power comes from coal.\(^2\) The extraction of coal, via mining and mountaintop removal, has high environmental and public safety costs. In addition, burning coal releases CO\(_2\), a recognized greenhouse gas that contributes to climate change. We need a sustainable, economically efficient alternative.

By further incentivizing, via state tax credits, the use of photovoltaic technology for powering homes, North Carolina would:

- Protect public health by reducing use of coal, which has impacts in multiple media,
- Reduce the amount of CO\(_2\) emissions, curbing climate change,
- Create incentives for companies to further produce photovoltaics, which would in turn drive down the costs of photovoltaic technology.

Incentivizing photovoltaic technology would decrease the demand for coal extraction, therefore reducing negative externalities that the environment and economy ultimately bear.

Data (below) have shown that tax breaks correlate positively with the amount of photovoltaic installations, as along with a decrease in the cost by 3.6% every year from 1998 to 2008.


Recent innovations have promoted the infiltration of PV systems into homes. As the technology has developed, the cost of PV systems has been steadily declining while the production has been increasing.

**Solar PV Global Production and Cost per Watt**

![Solar PV Global Production and Cost per Watt](source: Solar Buzz, Company reports, Green Econometrics research)
Because producers react to market demands, the more PV systems that are bought, the more are produced, in turn decreasing the price. State and federal tax subsidies significantly reduce the upfront cost of a PV module, therefore making it more accessible to all residents of North Carolina. This in turn increases the market demand which then also increases the production of PV systems and ultimately lowers the cost to the consumer, making PV modules even more attainable.

Without the state tax credits subsidizing PV modules for residential use, PV modules are unattainable to average North Carolinians because of up-front costs. Even though there is a strong interest among residents of North Carolina in installing PV modules on their homes, they are unable to install them because of the expense. This sends a market signal that there is no interest in PV modules, and industry does not spend resources on its development. Increased state subsidies help overcome the upfront cost barrier making PV modules more accessible to residents of North Carolina.

Right now, a lot of attention in the energy sector is focused on “clean coal” and reducing coal-fired power plant emissions. However, many of the pollutants from coal come from extraction, transportation, storage, and disposal. Spending energy and resources developing technology to clean up coal is highly economically inefficient when there are already technologies available that can sidestep the cleaning process altogether. Current proposals are failing since cleaning coal is economically inefficient when compared to switching to photovoltaics altogether. To create economically sustainable housing, we also need to consider the environmental costs and values.

In order to increase the number of photovoltaics installed in homes, government can work to incentivize the behavior as much as possible. Specific steps could include:

- Increasing the state tax benefits
- Appropriate funds for advertisement and education to consumers of photovoltaics
- Tax breaks to startup companies in renewable energy sector

The acquisition of renewable energy systems in the residential sector is an exciting development that has tangible benefits, and allows North Carolina residents to directly participate in carbon emission reduction.

ENVIRONMENT

Importance of the Problem

Global warming, diminishing resources, and the protection of our environment have become increasingly important in the 21st century. While home construction can be a confounding process, especially when trying to accommodate the various needs of home buyers, these issues must be addressed in the building sector not only through policy changes but also by providing incentives to encourage environmentally preferable practices through building codes, public pressure, and markets. While there are a variety of concerns, for the purposes of this policy brief we have focused on four aspects of environmental performance in the building process: indoor air quality, energy and water efficiency, materials and resources, and appropriate sites.

Current and Recommended Policy

Indoor Air Quality

With an increasing focus on energy conservation, building envelopes are becoming steadily tighter and there is much less natural exchange of air. New buildings, in large part, now rely on mechanical, forced-air ventilation systems in order to dilute indoor air with outdoor air. Inside homes, people unknowingly face many respiratory hazards. These hazards include: molds caused by excess moisture, gases from poorly ventilated combustion appliances, environmental tobacco smoke, formaldehyde, radon, VOCs from household products and paints/finishes, and particulate matter from cooking or from dirty surfaces. Proper forced-air ventilation should be considered an imperative amenity for the modern building; however, the current building codes do not require some vital exhausting measures. The following is a 2010 EPA quote from The Inside Story: A Guide to Indoor Air Quality, written by the U.S. EPA Office of Air and Radiation:

“In the last several years, a growing body of scientific evidence has indicated that the air within homes and other buildings can be more seriously polluted than the outdoor air in even the largest and most industrialized cities. Other research indicates that people spend approximately 90 percent of their time indoors. Thus,
for many people, the risks to health may be greater due to exposure to air pollution indoors than outdoors.”

**Ventilation:**

Many aspects of housing ventilation are already regulated by the 2009 NC Mechanical Code, such as the proper ventilation of uninhabited space (attics and crawl spaces), as well as the exhaust discharge clause, which states that “The air removed by every mechanical exhaust system shall be discharged outdoors at a point where it will not cause a nuisance and not less than the distances specified in Section 501.2.1.” It also states that the air shall be discharged to a location from which it cannot again be readily drawn in by ventilation. The 2009 NC Mechanical Code does not, however, contain any clauses about the requirement of direct atmospheric ventilation of combustion appliances, such as gas water heaters and furnaces, which can release harmful combustion by-products back into the house.

**Domestic Kitchen Exhaust Equipment:**

The following is a quote from the 2001 paper *Ultrafine Particles and Nitrogen Oxides Generated by Gas and Electric Cooking* written by M. Dennekamp et al.

> “Cooking in a poorly ventilated kitchen may give rise to potentially toxic concentrations of numbers of particles. Very high concentrations of oxides of nitrogen may also be generated by gas cooking, and with no extraction and poor ventilation, may reach concentrations at which adverse health effects may be expected. Although respiratory effects of exposure to NOₓ might be anticipated, recent epidemiology suggests that cardiac effects cannot be excluded, and further investigation of this is desirable.”

**Exhaust Equipment:**

The 2009 NC Mechanical Code states that “where domestic range hoods and domestic range appliances equipped with downdraft exhaust are located within dwelling units, such hoods and
appliances shall discharge outdoors….and shall be air tight and equipped with a backdraft damper.”¹ One issue is that many homes are not equipped with exhaust hoods and instead have microwaves above their stoves. Instead of pulling air outside, small amounts of air are pulled through filters that circulate the “filtered” air back into the house. This is ineffective because these microwave fans are weak in comparison to a hood, and the filters do very little to clean the air; many people do not ever change or clean these filters. In conclusion, they do very little to improve upon the indoor air quality of the house.

**Volatile Organic Compounds**

No current code regulations were accessible concerning the residential use of paints, primers, floor coatings, and varnishes with respect to VOC content. However, this does not mean that they are nothing to fear; VOCs have become an area of major concern to buyers and builders, and informal standards that focus on low-VOC paints, primers, floor coatings, and varnishes are beginning to emerge. Some people even recommend doing away with carpeting inside of housing due to their VOC content. Volatile organic compounds vaporize at room temperature according to the EPA; some of the short-term effects in humans due to VOC exposure are “eye and respiratory tract irritation, headaches, dizziness, visual disorders, and memory impairment.”² The same article also states that “many organic compounds are known to cause cancer in animals; some are suspected of causing, or are known to cause, cancer in humans.”

**Policy Recommendations for Indoor Air Quality:**

- Requirement of direct atmospheric ventilation of combustion appliances such as gas water heaters and furnaces.
- Hood exhaust systems with the specifications from the 2009 NC Mechanical Code, and which pull 100 cubic centimeters of air, should be a requirement in new housing construction and renovation.

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- Required bathroom ventilation, exhausting a minimum of 50 cubic centimeters of air directly outdoors, in order to reduce moisture levels and mold growth.
- Required low to zero VOC paints, primers, stains, floor coatings, and varnishes. (See http://www.sherwinwilliams.com/pdf/specifications/SW_LEED_VOC_ReferenceGuide.pdf for a 2010 list of suitable products.)

Optional Housing Certifications for Indoor Air Quality:
There are programs that have guidelines and checklists for consideration of indoor air quality in the construction of houses. These include but are not limited to LEED AP and Energy Star. There is an EPA program called Indoor airPLUS, which is designed to provide an indoor air quality certification label to Energy Star-rated homes. It is considered one of the best certifications currently available due to the fact that many of its requirements are merely recommendations or are simply not mentioned in other programs. The full specifications to the EPA airPlus program can be found at: http://www.epa.gov/indoorairplus/construction_specifications.html

Energy and Water Efficiency
Many houses today are built quickly and with little apparent emphasis on energy or water conservation. Also, those with low-incomes are often stuck with homes that are highly inefficient, wasting excessive amounts of both energy and water. In North Carolina, low-income households spend roughly 17% of their incomes on energy, compared to about 4% of other households’ incomes. Improving energy and water efficiency would be very beneficial for all homeowners in North Carolina, especially those in the low-income range.

Due to the high demand in North Carolina for heating in the winter and cooling in the summer, the state is one of the highest per capita consumers of electricity in the U.S. Improving energy and water efficiency within existing homes and newly built homes will not only benefit homeowners financially across the economic spectrum by providing more affordable housing and upkeep, but it will also help to improve conservation of our resources and will reduce North Carolina’s dependence on energy in general, which will be critical in coming years as our current energy resources dwindle.

The biggest problem regarding energy and water efficient houses in NC is that the building code used is outdated and is not well-enforced. Currently North Carolina’s building
code is based on the 2006 International Energy Conservation Code (IECC), including amendments. North Carolina could drastically increase overall residential energy savings by adopting the 2009 IECC building requirements.

The 2009 IECC makes some important improvements to the 2006 IECC code being used currently. There are three main sections concerning energy and water efficiency that are covered: the building’s thermal envelope, appliance efficiency, and insulation. Concerning a building’s thermal envelope, the 2009 report provides stricter testing requirements for sealing ducts as well as an overall improvement in thermal envelope requirements (for a full comparison of envelope requirements see Appendix A, table 3). Concerning appliance efficiency, it also requires that 50% of the lights used in houses are high-efficiency, such as Energy Star-qualified lights. While this is a positive step, the housing codes in North Carolina should call also for water-efficient faucets and appliances as well as water-conservation measures. Regarding insulation, the 2009 code calls for a slab-on-grade insulation of R-10 rather than R-5 with depth of 2 feet, as well as lower maximum fenestration U-values. The effect of these measures is that houses will need less energy for heating in the winter as well as less energy for cooling in the summer (for a list of notable requirements in the 2009 IECC Please see the Appendix A, 2.a).

In September of 2010, the North Carolina Building Code Council voted against taking any action concerning the adoption of the 2009 IECC report as the state’s building code until the next code cycle update. Contrary to the Building Code Council’s decision, the 2009 IECC report should be used as the building code for North Carolina as soon as possible. In an energy analysis comparing the 2009 IECC to the 2006 North Carolina Building code, there was a 15% decrease in annual energy costs. Also, buildings constructed to meet the 2009 IECC requirements have been known to use 30% less energy than houses build under the current code. The adoption and proper enforcement of this code would help reduce the energy burden on households in North Carolina and would make houses run more efficiently with less energy and less use of water.

North Carolina also should begin using renewable energy sources to heat and cool homes. In the summer there is ample sunlight across the country and we could make use of solar panels, solar hot water pumps, and other heating systems such as geothermal hot water heaters. While these measures are not the most cost-effective initially, they do have long-term energy-savings gains and thus financial benefits as well.

**Policy Recommendations for Energy and Water Efficiency**

The biggest problem is the implementation of measures ensuring energy and water efficiency within the building sector as there are no strict guidelines for ensuring that these measures in building codes, whichever code is being adopted by North Carolina, are carried out. If the state wants to make realistic steps in making its building sector environmentally friendly, it should take advantage of Federal organizations designed to assist in the implementation and regulation of energy efficient policies and programs. One of these is the Energy Code Ambassadors Project, which trains states to achieve 90% compliance of energy codes (for more programs and links see Appendix A, 2.b). North Carolina’s government should enforce the building codes and regulations on key aspects of energy efficiency by improving the inspection process. Following are some of the policies that the North Carolina State Energy Plan has brought into conversation as of 2005:

- Creation of an Energy Code Enforcement Assistance Program to provide additional energy code enforcement and outreach officials to serve across the state.
- The State Energy Office should investigate technologies, incentives, financing options, and regulatory issues regarding minimum efficiency requirements for manufactured housing.
- The State Energy Office should organize a statewide effort to develop criteria for a high-performance building program to reduce the life cycle cost of new and existing buildings
- Implementing promotions and incentives for high-performance buildings
- Training on new technologies for builders, building training for building professionals and others (for the NC State Energy Plan, see appendix A, 2.c).

Again, while these policy options are helpful, they are only recommendations and possible plans. The first steps to attaining long-term energy and water efficiency in NC is to
begin using the 2009 IECC building code as a model and to improve the process of implementation by creating incentives through policy.

**Materials and Resources**

Using materials and resources efficiently and sustainably is a very important strategy. Harvesting raw materials for consumption contributes to a variety of problems including deforestation, habitat destruction and global warming. It is also important to conserve natural resources for future generations. Furthermore, the transport and manufacturing process behind converting raw materials into useable form is also a major contributor to global warming and a major consumer of energy. Once materials are consumed, they usually end up in a landfill, and space in landfills is shrinking quickly. Materials and resources need to be handled in a sustainable fashion in order to mitigate all of these impacts.

First, resource efficiency—utilizing materials sustainably—should be common practice. This means using materials that are recycled, plentiful, renewable, locally available, salvaged and/or durable. The State of California has a comprehensive definition of the characteristics of resource-efficient materials at [http://www.calrecycle.ca.gov/greenbuilding/materials/](http://www.calrecycle.ca.gov/greenbuilding/materials/). Secondly, innovative designs can drive the sustainable use of materials and resources. Many innovative designs require less material, such as advanced wall framing (guidelines can be found at [http://www.toolbase.org/PDF/DesignGuides/advancedwallframing1.pdf](http://www.toolbase.org/PDF/DesignGuides/advancedwallframing1.pdf)), and plumbing systems running through the same wall and avoiding the use of extraneous materials. Designs should also focus on generating less waste by doing things like reducing the amount of temporary supports or reducing specialized cutting. Thirdly, construction waste can be drastically reduced by following a C&D Waste Management Plan. According to the Whole Building Design Guide (WBDG), the vast majority of construction waste and demolition debris materials can be reused on site, salvaged for reuse on-site or elsewhere, or recycled. A 90% reduction of construction job waste to landfills is not uncommon. More information about construction waste management can be found at [http://www.wbdg.org/resources/cwmgmt.php](http://www.wbdg.org/resources/cwmgmt.php).

Presently, there are a variety of voluntary programs that exist containing guidelines and checklists for the consideration of the sustainable use of materials and resources in the construction of houses. Of these, the LEED system (Leadership in Energy and Environmental
Design), developed by the US Green Building Council, contains the most comprehensive guidelines for sustainable material and resource use. However, building practices are extremely entrenched and require strong incentives for change. Resource efficiency should be encouraged by creating tax incentives or rebates for building with sustainable materials. Innovative designs such as advanced wall framing should be required and integrated into building codes and ordinances. Finally, construction waste management plans should be required or incentivized through tax or fee breaks.

**Site Selection and Development**

The site chosen for development is important in limiting the environmental impact of the future house. Furthermore, the construction process itself can have disastrous effects on the surrounding ecosystem. Site disturbance can contribute to soil erosion, waterway sedimentation, airborne dust generation and carbon dioxide emissions from soils that once stored the greenhouse gas. These consequences can be exponentially higher at construction sites; for example, sediment run-off rates from construction sites can be up to 20 times greater than agricultural sediment loss and 1000-2000 times greater than those of forested lands\(^1\). Also, compaction of the area’s soil from the use of heavy machinery and excessive foot traffic damages the soil structure and reduces infiltration rates, which in turn increases runoff volume and flooding\(^1\). Efforts such as the preservation of already on-site vegetation help with both limiting site disturbance and preserving the flora of the specific eco-region. Ultimately, sustainable sites and site development take into account the importance of maintaining the area’s environmental functionality and mitigating the associated negative effects of homebuilding.

Presently, guidelines concerning site selection and site development are limited only by zoning or residential subdivision regulations (such as minimal open space requirements). The Comprehensive Plan for Chapel Hill, adopted in May 2000, also sets regulations according to density threshold and developmental ability of the area in question. This plan aims to limit development within areas important to watershed and water source health (including the 100-year floodplain, and steep sloping areas) as well as within other areas, taking away from the connectivity of both naturally and culturally important open spaces. However, many of these guidelines are limited to large-scale development and should also target site selection and land

use within individual lots of land. This is why new guidelines should regulate site selection, on-site construction practices, landscape choices, and the requirement of stormwater and hydrology maintenance when building a home.

**Policy Recommendations for Site Selection and Management**

**Site Selection**
The first step to build in a sustainable way is to avoid developing in/on inappropriate areas that heighten the possibility that the house will affect neighboring ecosystems and species. Furthermore, to limit the negative effects of urban sprawl, regional access to public services such as public transit should be encouraged. Many of the following policy recommendations are adopted from LEED guidelines on site selection.

- Do not allow development of soils designed as prime farmland, unique farmland and farmland of statewide importance.
- Do not allow development on lands below an agreed-upon elevation.
- Do not develop in areas that interfere with floodplain function.
- Do not allow development close to a body of water. The Clean Water Act limits development within 50 feet of a body of water, but this regulation should be expanded to ensure maximum water health protection.
- Do not allow development in parkland.
- Do not allow development near or in areas of valuable ecosystems (wetlands, etc.)
- Where possible sites should take advantage of (currently available or possibly emerging) technology that will limit energy usage (such as geothermal power).
- Channel development to urban areas of existing infrastructure. This will promote and encourage non-motorized transportation and use of public transit and will also limit urban sprawl.

**On Site Construction**
Construction practices can have highly negative impacts on the surrounding ecosystems and therefore new regulations to limit these stressors should be implemented. Regulations should account for site disturbance, compaction and conservation of existing natural areas. By creating
guidelines that aim to control the negative consequences imposed during the construction process, the immediate watershed and air quality will be improved as well as the immediate biodiversity of the area. Future policy plans should include:

- Regulations or incentives for limits to site disturbance.
  - Required limits on soil disruptions aimed at reducing soil erosion, sedimentation, and airborne dust generation.
- Regulations aimed at limiting soil compaction.

**Landscaping**

Sustainable landscapes provide for the reduction of greenhouse gas emissions, the control of the introduction and spread of invasive species, and the limitation of waste-water and water pollution, as well as the limitation of yard waste. Not only do many of these sustainable landscape techniques save the homeowner monetary expenses but they also have positive feedback loops as they reduce the amount of resources needed for maintenance, further reducing the home’s stress on the environment. Policy plans should include landscaping regulations that take into account the following recommendations:

- Conservation of existing natural areas and restoration of damaged areas to provide habitat and promote biodiversity.
  - Incentives for the rescue and transplant of already on-site plants.
  - Regulations within individual plots of land that require the conservation of a percentage of the existing natural areas.
  - Preserve or restore appropriate plant biomass on site.

- Control and manage invasive plants found on-site. Do not allow use of invasive species and/or non-native species during landscaping of the area.
- Use appropriate non-invasive (adaptive) and native plants.
- Preserve all vegetation designated as special status.
- Use vegetation to minimize building’s heating/cooling requirements and reduce urban heat island effects. Provide shade with landscaping trees.
- Design the site to minimize or eliminate the use of potable water for landscape irrigation by 50% of baseline.
Stormwater and Hydrology Maintenance

The site also should be developed carefully in order to protect the environmental ecosystem functions of the area and to mitigate the negative effects imposed by stormwater runoff. The building of each house should take into account the following recommendations in order to limit their footprint on the outside watershed's health:

- Impose regulations that limit impervious surfaces as a percentage per lot to reduce quantity of runoff.
- Require the use of pave systems that encourage on-site infiltration, such as open-grid pavement systems.
- Require development to protect and restore existing functions (area’s hydrology).
- Protect/restore riparian, wetland and shoreline buffers.
- Require homeowners to manage and clean water on site to eliminate pollution from stormwater run-off and eliminate contaminants.
- Provide incentives for the design of rainwater/stormwater features to provide landscape amenity.
  - Allow/encourage the building of rain gardens.
EQUITY

Importance of the Problem

Equity with respect to homes entails several components, such as regional accessibility to key services, construction labor practices, consumer education, disability access and affordability. Elements of these components can be found throughout this document, but for the purposes of this exercise, we will be focusing on Universal Design, visitability, and affordability, as well as a few current relevant policies: the ADA, FHAA and IHDA.

When it comes to accessibility in homes, there is a general apparent lack of interest on the part of most Americans. Many people believe that making a home that is accessible to physical disabilities is something that does not apply to them, and is only reserved for only those who are elderly or have mobility limitations. Other popular ideas are that the incorporation of accessibility, universal design and visitability throughout the home would reduce the ability to customize and create a more institutional, less personal look. However, the inclusion of these measures does not hinder customization of the home, and home accessibility serves people of all ages and stages of life. In reference to the IHDA (See Appendix C), Rep. Jan Schakowsky (D. IL) appropriately states: “It defies logic to build new homes that block people out when it's so easy and cheap to build new homes that let people in.” Most people unexpectedly undergo some form of disability in their lives, and are living longer lives than ever before. When either of these situations occurs, people are forced to make adjustments to their daily routines that can often involve costly renovations or extra services to accommodate their changing conditions. By initially including the three basic visitability elements in the homes design, these future costs and adjustments could be avoided.

According to Eleanor Smith, the founder of Concrete Change, “visitability” is broadly defined as “a movement to change home construction practices so that virtually all new homes—not merely those custom-built for occupants who currently have disabilities—offer a few specific features making the home easier for mobility-impaired people to live in and visit.”

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2 Stanley K. Smith, Stefan Rayer, Eleanor A. Smith. “Aging and disability: Implications for the Housing
Smith outlines the three basic components of visitability:

- At least one zero-step entrance approached by an accessible route on a firm surface no steeper than 1:12, proceeding from a driveway or public sidewalk
- Wide-passage doors and hallways
- At least one half-bath on the main floor suitable for wheelchair access

Very few cities have passed ordinances mandating that new homes be built with visitability measures. Even fewer have made standard doorways at least 36 inches wide, a bathroom on the bottom level of multilevel homes, at least one entrance that has zero to one steps, or a ramp when terrain requires. One 1998 study by Steinfeld, Levine, & Shea stated that 90% of residential living units are inaccessible to those with disabilities. Placing an entrance 32-36” wide at ground level, with one step no higher than 1.0” or a ramp provides enough room for strollers, wheelchairs, furniture and other large household items to be moved in and out of the home easily, without damaging walls or door mouldings. In a multi-level home, it is necessary to have one bathroom on the ground level that is large enough to accommodate someone in a wheelchair or other physical impairment. In addition, the inclusion of a room that can become a bedroom on the first floor and a wheelchair accessible or curb-less shower is highly suggested. While a decorative grab bar beside the toilet to assist the physically handicapped is suggested, a wall capable of supporting such grab bars is a more necessary inclusion, should someone become unexpectedly injured.

If all states were to pass an ordinance that mandates all newly built homes have, at minimum, the three visitability features suggested by Eleanor Smith (one step-free entrance, doors at least 32” wide, and a main-floor toilet), then the percentage of homes that are supportive for all ages, families, and physical handicaps would drastically increase. Visitability benefits not only individuals with mobility limitations (both chronic, relating to aging or long-term disability, and unexpected or temporary, relating to injury or accident) and their families, but also society at large, given the significant costs to the public for otherwise unnecessary nursing and rehabilitation services when residents cannot access or live in their own homes. The cost to keep

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a loved in the hospital for an extended period of time or place them in a nursing home can be substantial. In the event that this occurs, governmental assistance is often needed.

“Universal Design” goes beyond basic visitability standards with an extensive menu of features, in efforts to create an environment that is supportive of all stages of life, including: families with small children, the elderly, and those who encounter various types of disabilities, including hearing and sight impairment.]

A few features of Universal Design that can be incorporated easily during the construction of a new home:

- Light fixtures approximately 36 inches above the floor
- Electrical sockets approximately 25 inches above the floor
- Lever handles for doors and faucets
- Counters and sinks at a height accessible for those physically handicapped or in wheelchairs
- Open space underneath sinks, and counter-top stove large enough for wheelchair access
- Floors with non-slip surfaces to prevent falls
- Wide straight stairs to accommodate movement of furniture or installation of a chair lift

Light fixtures at these heights make it possible for everyone to reach them. Lever door handles make it easy for everyone to open doors and turn water on and off, even if hand mobility is diminished. The counters and the sinks should be a height that is accessible for those in a wheelchair or physically handicapped. Underneath the sinks and the counter top stove there needs to be an open space that is large enough for the legs of someone in a wheelchair to be able access the stove top. The floors should have a non-slip surface to prevent anyone from falling— young children, the elderly, or physically impaired. A straight set of stairs, or stairs that are wide enough to accommodate a chair lift for someone disabled in the future is highly recommended.

Current Laws and Policies Reviewed:
- The Americans with Disabilities Act (ADA)

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The Fair Housing Amendments Act (FHA)
Inclusive Home Design Act (IHDA)

At all rungs of government, there are policies to support home accommodations for those who encounter physical disabilities during their lives. However, they appear to be largely disjointed, limited, and to some extent, not enforced appropriately. Also, they do not cover the significant share of the population who reside in single-family residences. The Americans with Disability Act, or ADA (see Appendix C), covers commercial buildings, and the Fair Housing Amendments Act, or FHAA (see Appendix C), covers multi-family homes. These acts are currently in force and have provided some relief to individuals with disabilities. However, they do not address some crucial access and equity concerns, including the needs of disabled renters. For instance, currently the responsibility among homebuilders, landlords, and disabled tenants are skewed, and should be more balanced. While the focus of the ADA is centered on discrimination, the FHAA focuses on the rights of an individual to make alterations to the home that they are leasing to accommodate their needs. Unfortunately, they seem to be solely responsible for any related costs.

Issues with the FHAA:
The Fair Housing Amendments Act (see Appendix C) insures that individuals with disabilities can make alterations to accommodate themselves. While requiring that landlords permit alterations, the tenant is held solely responsible for making the accommodations needed. They have to pay for the cost of all modifications done and removed if the landlord desires. The cost alone could force an individual to reside in home or area that can no longer meet their physical or emotional needs. For example, accommodating individuals who are confined to wheelchairs, use a walker or have difficulty walking up stairs, may require the installation of a ramp to the residence, at a cost of approximately $600.00. In addition there is the cost of installing grab bars in the bathroom, and if a resident is confined to a wheelchair, the exterior and interior entrances must be widened to enable the individual to move into and out of rooms.

2 Eleanor Smith, Director © 2010, Concrete Change http://www.concretechange.org/Concretechange.org
The Fair Housing Amendments Act (FHA) is an important Federal law that includes the essential elements of visitability for a home and gives citizens the right to report any violations; however it lacks specifics and covers only multi-family units, leaving the many residents of single-family residences without even these basic protections.\(^1\) The Inclusive Home Design Act (IHDA), pioneered by Eleanor Smith and highlighted in her recent Congressional testimony, specifically covers single-family homes. However, it is still only in the first stage of legislation.\(^3\) The proposed act was referred to the House Committee on Financial Services on Mar 10, 2009, but does not appear to have moved forward since then. The legislation applies only to new construction. The average added cost per home for the required features runs from $98 to $573. Adding accessible features after construction often costs several thousand dollars. It is important that more priority be given to this act in order to realize more far-reaching social and health benefits for the United States.

**Issues with the Current Building Codes:**

After rigorously searching for North Carolina state and local residential building codes specifying widths of doorways and entrances, our research team was unable to find any measurement data regarding the entrances of homes. According to section R331.3 of the 2006 NC Residential Building Codes, hallways should be no less than 3 feet (914 mm) wide (R311.3.1) and interior doorways to habitable rooms should be no less than 2 feet 6 inches (762 mm) wide and 6 feet 8 inches high (2032 mm) (R311.3.2).\(^2\)

Two feet, 6 inches (30 in) of width allows very little extra room for a person in a standard wheelchair (~26 in) to maneuver, as it would leave about 2 inches of free space on each side when centered in the doorway.\(^3\)

**Policy Proposals for Visitability and Access**

- Passing the Inclusive Home Design Act or one similar
- Aid to individuals with disabilities for the cost of alterations made to pre-existing homes in order to accommodate their needs
- Government aid to help subsidize the cost for necessary alterations for disabled residents

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• Amending and implementing polices and building codes that mandate at a minimum the following three visitability features incorporated into all new homes being constructed:
  o The dwellings have at least one building entrance on an accessible route, unless it is impractical to do so because of terrain or unusual site characteristics.
  o New homes be built with entrance and interior doorways 32-36 inches wide
  o A bathroom on the main floor
Appendix A

1. **Economy**

   a. To earn the Energy Star Home label the house must meet guidelines for efficiency set by the EPA; for example, these homes must be 15% more energy efficient than homes built by the 2004 International Residential Code (IRC) and include a number of energy saving features to make them 20-30% more efficient than standard homes.

   b. Energy conservation as the reduction in the total amount of energy consumed is essential to eliminate the ‘rebound effect.’ This happens when an increase in energy efficiency leads some residents to increase their demand for energy.

<table>
<thead>
<tr>
<th>Program</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>City of High Point Electric – Energy Stars New Home Rebate Program</td>
<td>$500 rebate to single family energy start certified homes</td>
</tr>
<tr>
<td>City of New Bern Electric – Energy efficient Rebate Program</td>
<td>Rebate to homeowners who install energy efficient water heaters and pumps</td>
</tr>
<tr>
<td>City of Statesville – Residential Energy Efficiency Program</td>
<td>Rebate to homeowners who install energy efficient water heaters and pumps</td>
</tr>
<tr>
<td>Duke Energy – Residential Energy Efficiency Program</td>
<td>Offers a rebate of $200 paid to qualified heat pumps and HVAC systems</td>
</tr>
<tr>
<td>Four County EMC – Residential Energy Efficiency Appliance Rebate Program</td>
<td>Offers a $150 rebate for energy start appliances</td>
</tr>
<tr>
<td>Lumbee River EMC – Residential and Commercial Energy Efficiency Program</td>
<td>Offers rebates to customers who purchase qualified energy efficient products</td>
</tr>
<tr>
<td>Piedmont EMC – Residential Energy Efficient Heat Pump Rebate</td>
<td>Offers financial incentive for its residential members who install energy efficient heat pumps</td>
</tr>
<tr>
<td>Piedmont Natural Gas – Residential Equipment Efficiency Program</td>
<td>Offers rebates on high-efficiency natural gas tankless water heaters, and furnaces</td>
</tr>
<tr>
<td>Progress Energy Carolinas – Residential Energy-Efficiency Rebate Program</td>
<td>Provides incentives for residential customers to increase home energy efficiency</td>
</tr>
<tr>
<td>PSNC Energy – Energy Efficient Appliance Rebate Program</td>
<td>Offers rebates to customers who purchase energy-efficient natural gas heaters or furnaces</td>
</tr>
<tr>
<td>South River EMC – Energy Star Homes Rebate Program</td>
<td>Offers incentives to home buyers who purchase or construct Energy Star certified homes</td>
</tr>
<tr>
<td>TVA Partner Utilities – <em>energy right</em> New Homes Program</td>
<td><em>Energy right</em> New Homes Plan provides incentives for all-electric, energy-efficient new homes by offering graduated rebates</td>
</tr>
<tr>
<td>Carteret-Craven Electric Cooperative –</td>
<td>Offers low-interest loans to help residential members</td>
</tr>
<tr>
<td>Energy Conservation Loan Program</td>
<td>improve energy efficiency in their homes</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Four-County EMC – Residential Energy Efficiency Loan Program</td>
<td>Offers Comfort Loan Program which offers financing for insulation upgrades, replacement of appliances, and purchase of energy-efficient water heaters</td>
</tr>
<tr>
<td>Haywood EMC – Residential Heat Pump and Weatherization Loan Program</td>
<td>Offers low-interest loan to their residential customers to finance purchase of an energy-efficient heat pump and weatherization measures</td>
</tr>
<tr>
<td>Lumbee River EMC – Residential Weatherization Loan Program</td>
<td>Offers low-interest loans of up to $10,000 to increase energy efficiency in residential homes</td>
</tr>
<tr>
<td>Piedmont EMC – Residential Energy Efficiency Loan Program</td>
<td>Conservation loan program available to consumers to finance the purchase and installation of certain energy efficient appliances</td>
</tr>
<tr>
<td>Progress Energy Carolinas – Residential Energy Efficiency Loan Program</td>
<td>Provides financing to help residential customers install energy saving products in their homes</td>
</tr>
<tr>
<td>Tideland EMC – Weatherization Loan Program</td>
<td>The loan will cover the purchase and installation of energy efficient measures</td>
</tr>
<tr>
<td>TVA Partner Utilities – energy right Heat Pump Program</td>
<td>Promotes the installation of high-efficiency heat pumps in homes</td>
</tr>
<tr>
<td>Union Power Cooperative – Residential Energy Efficient Heating Heat Pump Loan Program</td>
<td>Offers low interest loans to help finance new energy-efficient heat pumps</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Duke Energy – Energy Star Homes Rate Discount Program</th>
<th>Energy Star Homes Program awards a rate discount to customers living in Energy Star homes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progress Energy Carolinas – Rate Discount for Energy Star Homes</td>
<td>Offers incentive to its residential customers for improving energy efficient of their homes</td>
</tr>
<tr>
<td>PSNC – Residential Energy Efficiency Rate Discount Program</td>
<td>Rebate discount available to residential customers whose home meets the Energy Star for Homes qualification standards</td>
</tr>
<tr>
<td>Randolph EMC – Energy Efficient Rate Discount Program</td>
<td>Offers a special electric bill discount to its members who increase the energy efficiency of their homes</td>
</tr>
</tbody>
</table>

Source: [http://www.dsireusa.org/incentives/index.cfm?re=1&ee=1&spv=0&st=0&srp=1&state=NC](http://www.dsireusa.org/incentives/index.cfm?re=1&ee=1&spv=0&st=0&srp=1&state=NC)
Table 2: Simple payback period of Energy Efficient Appliances

<table>
<thead>
<tr>
<th>Appliances</th>
<th>Payback for energy-efficient appliances</th>
<th>Annual Life Cycle Cost $US*</th>
<th>Savings* $US</th>
<th>Simple Payback Period (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Energy Star</td>
<td>Conventional</td>
<td></td>
</tr>
<tr>
<td>Clothes Washer</td>
<td></td>
<td>$1,530</td>
<td>$1,752</td>
<td>$223</td>
</tr>
<tr>
<td>Dishwasher</td>
<td></td>
<td>$850</td>
<td>$922</td>
<td>$71</td>
</tr>
<tr>
<td>Freezer</td>
<td></td>
<td>$960</td>
<td>$994</td>
<td>$33</td>
</tr>
<tr>
<td>Refrigerator</td>
<td></td>
<td>$1,583</td>
<td>$1,653</td>
<td>$71</td>
</tr>
<tr>
<td>Dehumidifier</td>
<td></td>
<td>$1,114</td>
<td>$1,339</td>
<td>$225</td>
</tr>
<tr>
<td>Central Air Conditioners</td>
<td></td>
<td>$8728</td>
<td>$9,915</td>
<td>$1,187</td>
</tr>
<tr>
<td>Room Air Conditioners</td>
<td></td>
<td>$1,244</td>
<td>$1,299</td>
<td>$55</td>
</tr>
<tr>
<td>Heat Pump</td>
<td></td>
<td>$17,573</td>
<td>$19,758</td>
<td>$2,186</td>
</tr>
<tr>
<td>Furnace</td>
<td></td>
<td>$9,364</td>
<td>$10,289</td>
<td>$925</td>
</tr>
<tr>
<td>Air Cleaners and humidifiers</td>
<td></td>
<td>$443</td>
<td>$597</td>
<td>$154</td>
</tr>
</tbody>
</table>

*Life cycle cost was calculated using operating cost, energy cost, energy consumption (kWh), maintenance cost and purchase price


2. Energy and Water Efficiency

      
      i. Building envelope must be caulked and sealed.
      
      ii. Slab-on-grade insulation is R-10 to a depth of 2 feet in Zones 4 (this is the zone Orange county falls into) and 5. Insulation is not required for
      
      iii. Slab-on-grade foundations in Zone 3.
      
      iv. Supply ducts in attics must be insulated to R-8. Return ducts in attics and all ducts in crawlspace, unheated basements, garages, or otherwise outside building envelope must be insulated to R-6.
      
      v. All ducts must be sealed and either:
1. **verified by pressure testing** – the duct system has to be tested and the air leakage out of ducts must be kept to an acceptable maximum level.

2. **installed entirely within the building thermal envelope** – testing is not required if all ducts are inside the building thermal envelope (for example in heated basements), though the ducts still have to be sealed.

**vi.** Piping for hydronic (boiler) heating systems must be insulated to R-3.

**vii.** Although vapor retarders are not required by the IECC, the I-codes do set wall vapor retarder requirements in Section R601.3 of the 2009 IRC, and vapor retarders are required in Zone 5.

**ix.** Less insulation is allowed for mass walls and more insulation is required for steel framing.

**x.** 50% of the lighting “lamps” (bulbs, tubes, etc.) in a building must be high efficacy. Compact fluorescents qualify, standard incandescent bulbs do not.

**xi.** Standard I-code administrative requirements (inspections, documentation) apply.

**xii.** A certificate must be posted near the electrical panel listing insulation levels and other energy efficiency measures.

**xiii.** R-3 pipe insulation on hydronic distribution systems (increased from R-2)

**xiv.** Stricter area limits on door exemptions

**xv.** Improved (more detailed) air-sealing language

**xvi.** Snow melt controls

**xvii.** Pool covers are required for heated pools

**b.** Programs and organizations that assist in regulation and implementation of conservation of energy in the building sector:

**i.** Energy Code Ambassadors Project.
Website: [http://bcap-ocean.org/resource/energy-code-ambassadors-project](http://bcap-ocean.org/resource/energy-code-ambassadors-project)

**ii.** State Energy Efficiency Action Network (SEE) – Federal program designed to assist states and local governments in implementing efficiency policies and programs. It is designed to remove barriers and disincentives to realizing energy savings through efficiency as well as to increase state-level investments in cost-effective energy efficiency. It also provides funding for state policies and programs which encourage energy efficiency.
Website: [http://www1.eere.energy.gov/office_eere/see_action.html](http://www1.eere.energy.gov/office_eere/see_action.html)

**iii.** North Carolina Weatherization Assistance Program – Department of Energy’s contribution to state governments to enable low-income families to acquire higher levels of energy efficiency in their homes. The NC government has plans to analyze its effectiveness. Also, the State Energy Office has plans on developing further programs to address energy-efficient housing in the low-income sector.
Website: [http://www.energync.net/Weatherization.pdf](http://www.energync.net/Weatherization.pdf)

iv. North Carolina Energy Efficient Alliance
Website: [http://www.ncenergystar.org/](http://www.ncenergystar.org/)
[http://www.energync.net/epc/docs/Energy%20Plan%202005.pdf](http://www.energync.net/epc/docs/Energy%20Plan%202005.pdf)

### Table 3: Comparison of Envelope Requirements between the current NC Building Code and the 2009 IECC

<table>
<thead>
<tr>
<th>Climate Zone 3A</th>
<th>Climate Zone 4A (Orange County)</th>
<th>Climate Zone 5A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling (r-values)</td>
<td>30 30</td>
<td>38 38</td>
</tr>
<tr>
<td>Skylight U-factor</td>
<td>.65 .65</td>
<td>.60 .60</td>
</tr>
<tr>
<td>Fenestration U-factor</td>
<td>.65 .50</td>
<td>.40 .35</td>
</tr>
<tr>
<td>Fenestration SHGC</td>
<td>.40 .30</td>
<td>.40 NR</td>
</tr>
<tr>
<td>Wood Frame Wall</td>
<td>13 13</td>
<td>13 13</td>
</tr>
<tr>
<td>Mass Wall</td>
<td>5/8 5/8</td>
<td>5/13 5/10</td>
</tr>
<tr>
<td>Floor</td>
<td>19 19</td>
<td>19 19</td>
</tr>
<tr>
<td>Basement Wall</td>
<td>0 5/13</td>
<td>10/13 10/13</td>
</tr>
<tr>
<td>Slab</td>
<td>0 0</td>
<td>5, 2 ft. 10, 2 ft.</td>
</tr>
<tr>
<td>Crawl Space</td>
<td>5/13 5/13</td>
<td>10/13 10/13</td>
</tr>
</tbody>
</table>
Appendix B

Integrating the Three E’s of Sustainability: The Case of Solar Hot Water

The idea of sustainability has long been focused on a single, narrow approach: how to mitigate or eliminate negative human effects on the environment. While this common idea of sustainability is important and correct, there has recently been a push for a more encompassing view. The three Es, environment, equity, and economy, are the essential pillars of this new movement. Each ‘E’ is essential and all of them are interconnected on so many levels that it may be difficult to distinguish among them. Solar hot water systems, which are one of the most common sustainable technologies on the market, are an excellent example of how the Es overlap. This case study will look at the Es individually and together, especially at the cost-benefit analysis of installation and maintenance.

Economics is the major focus of this analysis. The primary objections many citizens have to resource-conserving technologies are their cost. The evolution of solar heating systems in the US has always tracked closely with the economics. In the late 1800s, the first systems were installed in Baltimore. Over 67,000 units were installed at the peak of the first “golden age” of hot water heaters in the 1920s. By the 1950s though, electricity was so cheap that the economic advantage of SHW no longer existed and most of these systems were removed. The next resurgence came in the 1970s during the oil embargoes. As oil became more expensive, energy was linked to national security, and government subsidies were created, solar hot water enjoyed popularity and success. However, when oil prices fell and subsidies were discontinued, use declined again (Lane-1).

Recently tax credits have returned, along with a new public interest in becoming sustainable. With complicated laws on tax credits and the ever-changing energy market, knowing whether a SHWS may be economical for a given household is very important. For example, a SHWS would be more beneficial for a family of five living in a high-electricity-cost region like California than a single person living in a low-solar-intensity region like New England. Yet New England is much colder, so a SHWS could also be used for heating. The complexity of the many variables such as system cost, tax credits, local subsidies, local solar intensity, building orientation, system efficiency, and electricity cost make the simple economics difficult to understand. Many online calculators, which calculate estimated savings and buy-back times for SHWS, are complicated because of these factors. Another issue is that many
people do not have a general knowledge of the ‘numbers,’ like the R-value of their hot water tank or the solar intensity at their home. While these numbers may be easy to find, not understanding what they mean is a difficulty that brings us to another E, equity.

Equity is the E that many consider the most overlooked. Social, racial, economic, and educational equality are some of the larger issues that fall under this topic. They have an impact on how sustainability is reached as well as what sustainability is. There are two main pillars of equity in regards to SHWS: consumer education and capital costs. Education covers knowledge of solar systems and the benefits they bring, how to apply for loans and tax breaks, and how to ensure the system is properly installed and maintained. Having access to technologies and the ability to obtain a loan are two instrumental factors in spreading SHWS to lower socioeconomic classes. In addition to education, equity also ties in with simple economics: lower-income families that could seriously benefit from SHWS are not in a position to buy them.Either their credit score is too low for a loan or they do not have the capital to buy the system outright.

Perhaps the most visible E in the public’s eye is the environment. Protecting the world that gives us life is obviously important. Climate change is a major threat to human existence and prosperity; the droughts, severe storms, and higher sea levels associated with climate change can harm our society. Fossil fuel energy production also degrades air, water, and soil quality. As buildings consume 40% of the world’s resources, including around half of the energy produced in the US, increasing their efficiency can have a major impact on the environment. A solar hot water system (SHWS) reduces energy consumption in buildings by absorbing solar energy to heat water instead of using natural gas or electricity. It also can be used for space heating, although this is rare and restricted by location. The embodied energy of a SHWS is also low compared to other green technologies. No rare earth metals are used, with copper, steel, or aluminum the most common absorbers. The transfer fluids, typically an anti-freeze, are nontoxic and reusable. The most complicated pieces of equipment are the pump and computerized controller, which are common, simple products. Part of the beauty of the SHWS is how simple it is: A tank, pump, and collector are all you need. The largest benefit of SHWS are the avoided damages and pollution: Most electricity in the US comes from coal, an energy source that inflicts damage to the land (through mountain top removal), acid rain, climate change, and a whole host of other environmental and human health costs.

The solution for many of these problems is a revolving loan fund (RLF). This type of loan provides capital at the lowest interest rate possible, typically slightly above the inflation
rate. Money is loaned to projects that eventually repay the loan with the cost savings generated by the upgrade. Harvard University has instituted a RLF of $12 million for green upgrades on campus and has since saved $4 million in energy bills (Green-1). Orange County does not have the resources to invest this amount of capital, but smaller projects are also successful. The UNC Environmental Finance Center is a group focusing on collaborative training and financial assistance for environmental protection projects. Collaboration between the UNC and Orange County could provide opportunities for homeowners to upgrade and move the area towards carbon neutrality and a more sustainable world.
Appendix C

_Housing policy relative to equity_

It is an unlawful discriminatory housing practice to:

1. Refuse to permit, at the expense of a handicapped person, reasonable modifications of existing premises occupied or to be occupied by the person if the modifications are necessary to the handicapped person’s full enjoyment of the premises; except that, in the case of a rental unit, the landlord may, where it is reasonable to do so, condition permission for modifications on agreement by the renter to restore the interior of the premises to the condition, what is currently out there that existed before the modifications, reasonable wear and tear excepted.

2. Refuse to make reasonable accommodations in rules, policies, practices, or services, when these accommodations may be necessary to a handicapped person’s equal use and enjoyment of a dwelling;

3. Failure to design and construct covered multifamily dwellings available for first occupancy after March 13, 1991, so that:
   a. The dwellings have at least one building entrance on an accessible route, unless it is impractical to do so because of terrain or unusual site characteristics;
   b. With respect to dwellings with a building entrance on an accessible route:
      1. The public and common use portions are readily accessible to and usable by handicapped persons;
      2. There is an accessible route into and through all dwellings and units;
      3. All doors designed to allow passage into, within, and through these dwellings and individual units are wide enough for wheelchairs;
      4. Light switches, electrical switches, electrical outlets, thermostats, and other environmental controls are in accessible location
      5. Bathroom walls are reinforced to allow later installation of grab bars;
      6. Kitchens and bathrooms have space for an individual in a wheelchair to maneuver.

The Inclusive Home Design Act of 2009 (H.R. 1408) “requires, with exceptions, newly constructed, federally assisted single family houses and town houses to include at least one level that complies with the following accessibility features for persons with disabilities:

1. accessible entrance and interior doors
2. accessible habitable space and an accessible bathroom.

Requires:

1. Each applicant for federal financial assistance to submit compliance assurances to the relevant federal agency
2. Each person who arranges for design or construction of a covered dwelling to submit architectural and construction plans for state or local approval.

Prohibits: federal financial assistance to a state or local government unit unless the recipient is taking certain enforcement actions with regard to covered dwellings.

Permits:

1. Private civil actions in a U.S. district court or state court for violations under this Act
2. The Attorney General to commence civil actions or intervene in civil actions under this Act.”
Appendix D

*Integrating the Three Es of Sustainability: Earthships*

Sustainability is defined as the ability to “meet the needs of the present generation without compromising the ability of future generations to meet theirs.” Because sustainability has ecological, social, and economic implications, an effective framework of handling sustainability is through a comprehensive viewpoint known as the three Es: Environment, Economy, and Equity. Earthships are a type of home built from recycled materials that need little to no energy or water inputs. Earthships are a tangible example of a system where all three Es are fulfilled in the creation of a sustainable home model. This case study will look at how Earthships embody each of the three Es, and how they come together to make a sustainable system.

Earthships are a type of passive solar home design created by architect Michael Reynolds of New Mexico. The building technique of Earthships is to build a home with structural walls made of used automobile casings rammed with soil or clay stacked on top of each other like bricks. Because the wall is so thick and dense, the insulation (R-value) is so high that little to no energy is needed to heat or cool the home. Over the tires, stucco or adobe is applied for aesthetics.

Economy is one E (in the 3Es sustainability rubric) to consider. Earthships are made from almost 100% recycled materials which can be found in any urban or rural location, therefore significantly cutting down the material costs of building a house. Earthships are made to run on little or no outside energy, therefore significantly reducing or eliminating energy bills throughout the life of the home. Finally, the lifetime of materials in an Earthship are much longer than that of conventional wooden houses, therefore retaining its value for a longer period of time. Wood decomposes relatively quickly and is susceptible to mold, water damage, and termites. Tires buried inside of soil take thousands of years to decompose and are not as susceptible to outside damage. Because earth rammed tires are the main structure of the house, in the event of an earthquake the house moves with the land. Because the tires are made out of rubber, the structure is more pliable than a conventional home, thus more substantial against earthquakes.

Environment is a second E to address. “A typical, 2,000 square-foot, single-family home requires about 15,800 board feet of framing lumber and nearly 10,900 square feet of paneling and other wood products” (Idaho). This creates an extremely high demand for logging, which
has a multitude of negative environmental impacts. A rammed earth house greatly reduces the demand for logging by circumventing the market for wooden building materials. Also, tires are extremely difficult to dispose of and recycle. Using them as building materials keeps them out of landfills where they are often illegally burned. In North Carolina, most energy is produced by coal-fired power plants, which are often mined using mountaintop removal. This mining technique poisons the water table and streams by exposing heavy metals such as mercury and arsenic into the local water systems. The fact that Earthships make energy onsite using photovoltaic systems and small wind turbines reduces the demand for coal extraction. The front south window side of all earthships requires plants as part of the grey water filtration system. This setup creates a sort of greenhouse in which edible out of season plants can be grown. This greatly reduces the carbon impact of shipping out-of-season fruits and vegetables for domestic consumption.

The third and last E to discuss is Equity, specifically the feasibility and affordability of building an Earthship. The low-cost building materials of an Earthship (used automobile casings, glass bottles, and cans) make it more accessible to people that do not have access to market resources such as high-grade lumber. Most of the work of an Earthship involves ramming tires with dirt. This is very low-skilled labor that is accessible to any able-bodied person. The main tools needed to make an Earthship include a backhoe, which can be rented for about fifty dollars per hour, chain saw, sledgehammer, chain saw, and cement mixer. These are all generally accessible items.

The main obstacle to making this building practice a widespread reality is that building with rammed earth automobile casings is not recognized by the Uniform Building code (UBC). Without complying with the UBC, a permit cannot be acquired to build an Earthship. There is a clause within the UBC which allows for alternative building techniques “not covered in this document.” Therefore the only way right now to spread the building of Earthships is by proving to building code officials county by county that rammed automobile casings are a safe building technique. Even though this can be a long and arduous process, there is work currently underway to make alternative building styles like this more accessible.
Works Cited

SUSTAINABLE HOUSING-RELEVANT RESOURCES


ECONOMY


ENVIRONMENT


**EQUITY**


1. Interview with Richard Duncan- RL Mace UD Institute, [http://udinstitute.org/](http://udinstitute.org/)
2. The Need for More Accommodating Housing -UD Institute
3. Housing for the Lifespan of All People - UD Institute

**SOLAR HOT WATER CASE STUDY** (Works Cited for Appendix B)

*Green Campus Loan Fund.* Harvard University. <http://green.harvard.edu/loan-fund>


**EARTHSHIPS CASE STUDY** (Works Cited for Appendix D)
