Comparative Analysis of Energy Consumption Trends in Cohousing and Alternate Housing Arrangements

by

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Submitted to the Department of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil and Environmental Engineering

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ABSTRACT

The sizes of both single-family and multifamily homes have grown steadily in the United States over the last fifty years. During this time, despite more efficient production processes, energy consumption in the country also rose. The many concerns associated with increased energy consumption include hastening depletion of fossil fuel resources, increased dependence on foreign resources for fuel, environmental concerns related to fossil fuel emissions, and ensuring all people have access to economic energy sources. Awareness of the necessity to engage in more sustainable practices (environmentally, economically, and socially) has existed at least since the 1960s. The United Nations formalized these concerns in the 1987 publication, "Our Common Future" in which they defined and popularized the term "sustainable development." Despite this awareness and the continuing efforts of governmental and non-governmental agencies to reduce the impact of energy consumption, the rate of consumption has continued to rise and the rate of growth of energy consumption has only seen marginal improvements in the United States (and has risen dramatically in some developing countries such as China and India). One way to reduce the rate of consumption or slow the rate of growth is to reduce the impact of the United States housing market through demand management techniques and energy efficient construction. Cohousing offers one opportunity to accomplish that goal. This thesis outlines the background information related to U.S. energy consumption and housing trends, the relative impact of energy consumption in cohousing, and the challenges of implementing cohousing on a large enough scale to make an impact in nation-wide consumption trends.

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,BIOGRAPHICAL NOTE

Jason R. Brown was raised in Dyersville, IA and attended Iowa State University, graduating in December 1997. He served in the United States Navy's Civil Engineer Corps from 1998 until 2003. During his time in the Navy he served in Fort Worth, Texas and Seal Beach, California as a construction project manager and in Iwakuni, Japan as the facilities operations officer. In the spring of 2003, Brown earned his professional engineering license in the State of Iowa. He resigned his commission in April 2003 in order to attend the Massachusetts Institute of Technology and began his studies the following autumn.

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EXECUTIVE SUMMARY

Cohousing is an emerging housing option in the United States. From its modest beginnings in Denmark in the 1960s, through its introduction to the U.S. market in the 1980s, to today where more than 60 communities nationwide are thriving, cohousing has developed into a viable option for people of all demographics. When Kathryn McCamant and Charles Durrant published their seminal work, "Cohousing, A Contemporary Approach to Housing Ourselves" in 1988, the term cohousing had not yet been coined. Now it is understood to consist of a housing option that consists of resident participation in the planning and design process, intentional neighborhood design, extensive common facilities, and complete resident management as detailed in their work.

However, while cohousing has become increasingly popular, there is little understanding by business, financiers, the government, and even potential future residents on exactly how to approach cohousing. Business must ask, "Where is the economic value of cohousing? How is that value created? Who gets to take advantage of the value? How attractive is the cohousing market?" Financiers must ask many of the same questions with their primary concern being, "If I invest in this option, what risk will

I be assuming, and what return will I experience in order to be compensated for assuming that risk?" To determine whether or not cohousing is the appropriate choice for any individual or family, each person considering it as a living arrangement must understand the social, economic, and personal effects of choosing cohousing over other options. Finally, the government must understand the impact of cohousing on society and determine whether or not it is the type of choice they would like to encourage or not. If the government does choose to encourage cohousing they must decide in what form that encouragement would come (e.g. tax incentives, subsidies, etc.) and to what degree.

While research has been done regarding the social benefits of cohousing, very little has been done to determine the ecological impact of cohousing from an engineering standpoint. These impacts must be fully understood for all potential stakeholders to make informed decisions regarding their role (or lack thereof) in implementing cohousing. This thesis attempts to provide indicators of ecological impacts (specifically as it relates to energy demand in cohousing) and provide a foundation for future research to determine the costs and benefits of cohousing.

The first section of the thesis provides a literature review on a variety of topics related to the discussion. This section begins with a detailed history of cohousing, followed by the definition of sustainability and information relating to the emerging push toward sustainable development. Information is provided for national and regional housing trends and building techniques. Summaries of the United States National Energy Policy and its implications are also provided.

The second section investigates various case studies, examining the design and construction choices made by cohousing communities. The implementation of these design and construction choices have been analyzed by investigating the construction processes and energy consumed in operation of the infrastructure. Indicators pointing to the success or failure of these choices have been determined by comparing and contrasting the energy data to national, regional, and local control groups as appropriate.

Finally, conclusions are drawn relating to the economic and ecological sustainability of cohousing as a housing option, and the thesis closes with discussion regarding the potential future of cohousing, including the attractiveness of the option from residential, commercial, and governmental perspectives. A brief analysis of the market is provided and suggestions regarding each potential stake holder's role are offered by the author. Recommendations for further research are also provided.

This thesis is not intended to provide a definitive determination of the quality of cohousing as a housing option. However, it is intended to provide indicators of success and failure and highlight those areas where there appear to be opportunities to leverage technology, evolving management practices, or governmental policies to maximize the benefits of cohousing and reduce any potential negative impacts. While some Life Cycle Assessment (LCA) tools will be used, further research on a case by case basis would be necessary to determine the full life cycle impact of cohousing as compared to other housing options.

CHAPTER 1

COHOUSING

1.1 History of Cohousing

The living arrangement known today as "cohousing" in the United States, originated in Denmark in the 1960s. Danish architect Jan Gudman-Hoyer and his wife began looking for more desirable alternatives to urban living and agreed that neither single-family suburban houses nor multistory apartment buildings nor row housing were desirable alternatives. While each housing option had some benefits (e.g. privacy, community development, affordability), none of them met all of the needs and desires of Gudman-Hoyer and his wife (McCamant, 135).

In the winter of 1964, Gudman-Hoyer and a group of his friends gathered to discuss housing options. These discussions focused on the development of a more supportive living environment. According to McCamant and Durrett:

"They sought the qualities of a country village, but a location near the city with its professional and cultural opportunities. Agreeing that cooperation was as necessary at home as in the workplace, they decided their housing complex should be small enough to allow residents to know each other and to feel comfortable using the common areas as an extended living room. In addition, the design should encourage social interaction among neighbors; and, most importantly, 'a housing program should not be carried out for the people, but by the people'."

From these meetings, Gudman-Hoyer's group decided to develop a community that would satisfy their desires, and, to that end, bought a site in Hareskov (near Copenhagen) and developed plans for twelve units on the site. Due to resistance from the neighbors, the site was never developed by the Gudman-Hoyer group and was eventually sold.

Gudman-Hoyer continued to refine the initial ideas developed in the winter of 1964 and in 1968 published an article titled, "The Missing Link between Utopia and the Dated One-Family House." The article received responses from more than one hundred interested families and the movement took off. By 1972, two *bofoellesskaber* (Danish for "living communities"), *Satettedammen* in Hillerod and *Skraplanet* in Jonstrup, were occupied by a combined sixty families (McCamant, 135-139).

1.2 Cohousing in the United States

Motivated by many of the same desires that encouraged Gudman-Hoyer to begin the development of alternative housing options, American architects Kathryn McCamant and Charles Durrett traveled to Denmark to study the *bofoellesskaber* movement. In 1984 and 1985, McCamant and Durrett spent 13 months studying 46 cohousing communities in Denmark and published their results in "Cohousing, A Contemporary Approach to Housing Ourselves" in 1988. In their book they define cohousing by four common characteristics:

> "**Participatory Process:** Residents organize and participate in the planning and design process for the housing development, and are responsible as a group for all final decisions.
>
> **Intentional Neighborhood Design:** The physical design encourages a strong sense of community.
>
> **Extensive Common Facilities:** An integral part of the community, common areas are designed for daily use to supplement private living areas.
>
> **Complete Resident Management:** Residents manage the development, making decisions of common concern at community meetings," (McCamant, 38).

The cohousing movement caught hold in California and soon spread to the rest of the country. By the time the second edition of "Cohousing" was published in 1994, one hundred and fifty groups had formed to explore cohousing possibilities and more than a dozen had already procured a site.

As evidence that the cohousing movement is still evolving, an April 2003 press release by the Neshama Abraham Paiss, cohousing professional and member of Nomad Cohousing in Boulder, Colorado, offers two more characteristics of cohousing:

> "**Non-Hierarchical Structure:** Community members have leadership roles, but no single person is the leader of the community. In addition, community members work together to make decisions of common concern often choosing consensus as the decision-making model.
>
> **Separate Income Sources:** Although a large number of cohousing residents work from home, neighbors do not rely on the community for their source of income."

According to the press release in 2003, sixty-four cohousing communities in the United States have been formed, while an estimated 150 more communities are in various stages of planning and development. Figure 1.1 (on the following page) details the number of communities that were completed annually between 1990 and 2003 (Paiss, 1-5).

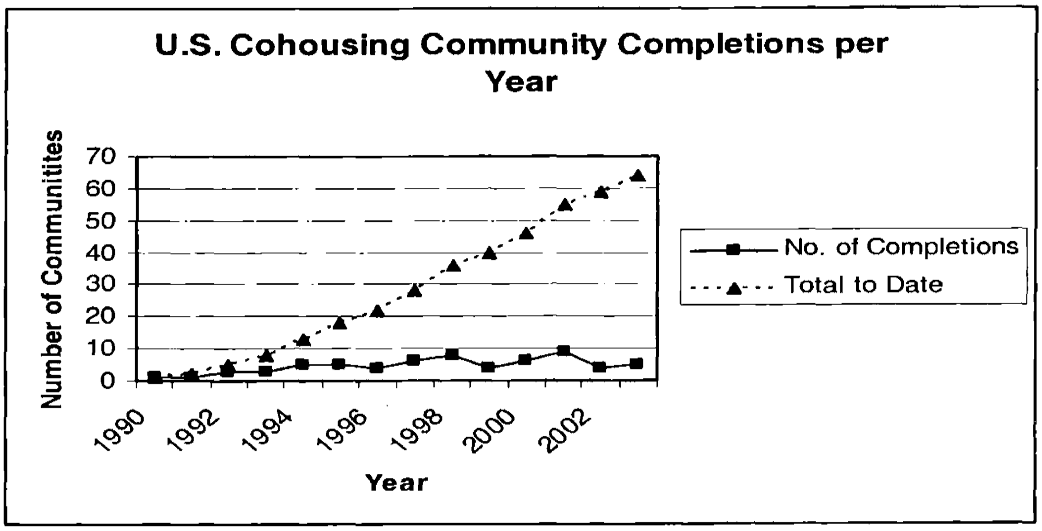

Figure 1.1: U.S. Cohousing Community Completions per Year
Source: Cohousing Journal, Spring 2002
Note: 2003 Data is derived from April 2003 press release noted above; some communities may have been completed in late 2002.

1.3 Why residents choose cohousing

The residents of cohousing communities are seeking the advantages implicit in the design of these communities: greater ability to share resources; providing a safe haven for all residents (especially children); a balance between privacy and a social atmosphere; a demographically diverse population including many races, age groups, and people of varying levels of income; environmental responsibility; and affordability. All of these features have been compromised to one degree or another in urban apartment dwelling or suburban single-family sprawl.

However, achieving the desired level of community is not easy. The planning and development process for cohousing is intensive. Most groups planning communities will lose members along the way (who must be replaced) as some become disenchanted with the process and the required level of effort to develop a community personally. It is much simpler to work with rental agents or realtors to find a home than it is to work with the bevy of consultants, designers, construction professionals, and financiers necessary to successfully implement the cohousing model. The cohousing development process requires a greater level of commitment and a greater assumption of risk than any other housing choice a potential resident could make. (This is obviously not as true about the residents that become involved after the community is formed as with those involved in the initial planning group.) But there are those that are willing to assume the risk, hoping that the benefits outweigh the costs.

1.4 Who chooses cohousing

Who are the people that are willing to accept the additional effort and risk in order to be a part of a larger community? In the same release noted above, cohousing residents are defined as "Cultural Creatives," a term coined by Paul H. Ray and Sherry Ruth Anderson in their book, "Cultural Creatives, How 50 Million People are Changing the World." The authors define cultural creatives as those whose actions are consistent with their beliefs and statements; those who take engaged action and are involved in "whole process learning;" those who value idealism and activism, globalism and ecology, and the importance of women in today's society[1] (Ray, 8-13).

Cohousers come to cohousing for a variety of reasons. Some appreciate the community, others the ability to simplify their life. Some see it as a more ecologically

[1] Ray and Anderson also provide various specific indicators of cultural creativity, and although there may be a very strong correlation between their definition of cultural creatives and residents of cohousing, it is an over-simplification to identify all cohousers as cultural creatives. The cohousing desire for diversity alone should prove that not all members of the movement can be defined by any one label.

sustainable way to live, and others may simply be seeking an affordable housing option. There are probably as many reasons to be a cohouser as there are cohousers. However, all of them believe, for whatever reason, that more common housing arrangements such as single-family homes, apartments, condominiums, or duplexes do not suit their needs as well as cohousing does.

1.5 Why Study Cohousing

While development of cohousing communities is a more viable option than it was as recently as twenty years ago, there is still a lack of scientific understanding regarding the true impact of cohousing environmentally, economically, and socially. According to the Fall 2002 issue of "The Cohousing Journal", at least 40 dissertations and theses have been written about cohousing. Most of the research focused on the social aspects, which is appropriate considering the primary objective of cohousing is to develop stronger communities, not reduce energy consumption. However, as cohousing becomes more popular it is important to analyze all of the unintended consequences (positive or negative) and quantify them in order to fully evaluate its impact as a living arrangement. The goal of this thesis is to evaluate and quantify the energy consumption at two cohousing communities and compare the results to national and regional averages. This analysis provides the first definitive evaluation of energy consumption at these communities and allows residents, researchers, and those developing future communities to evaluate the potential impact of cohousing as it relates to energy consumption.

The results of this thesis provide indicators of success or failure in the ability of cohousing to reduce energy consumption when compared to other living arrangements. Infrastructure that contributes to reduced energy consumption not only reduces the cost to the resident, it also adds value to the home and reduces pollution and environmental impacts from fossil fuel consumption. Only once the relative impact of the infrastructure's energy consumption has been quantified can stakeholders make informed decisions about the value of cohousing.

CHAPTER 2

RESEARCH BACKGROUND

An understanding of sustainable development, United States housing trends and energy consumption trends are necessary to understand the impacts of current housing practices and how a broader implementation of cohousing may help to offset those impacts. A brief description of each of these issues is provided in this chapter.

2.1 Sustainability

While the formal concepts of sustainability stretch at least back to the 1960s and sustainable practices were a part of everyday life in many pre-Industrial Revolution societies (e.g. Native Americans are believed to have considered the effects of their actions on the next seven generations) (Ray, 287-288), the term sustainable development was first popularized by the World Commission on Environment and Development, a committee within the United Nations and chaired by Gro Harlem Brundtland, which was charged with the formulation of a "global agenda for change." They defined sustainable development as ensuring that humanity meets the needs of the present without compromising the ability of future generations to meet their own needs[2] (Brundtland, 8).

The commission had four stated goals:

- "To propose long-term environmental strategies for achieving sustainable development by the year 2000 and beyond;
- To recommend ways concern for the environment may be translated into greater co-operation among developing countries and between countries at different stages of economic and social development and lead to the achievement of common and mutually supportive objectives that take account of the interrelationships between people, resources, environment, and development;
- To consider ways and means by which the international community can deal more effectively with environmental concerns; and
- To help define shared perceptions of long-term environmental issues and the appropriate efforts needed to deal successfully with the problems of protecting and enhancing the environment, a long-term agenda for action during the coming decades, and aspirational goals for the world community," (Brundtland, ix).

While some progress has been made to satisfy this mission, such as the limiting of CFCs through the Montreal Protocol, it is obvious that there is still work to be done. The

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[2] Despite this definition, sustainability remains an abstract concept as it is open for interpretation what future generations' needs will be and what resources and technologies they will have at their disposal to meet them. Additionally, the term "sustainable" is often used inappropriately, or too broadly, with little or no reflection of this initial definition.

world is consuming natural resources (especially fossil fuels) at ever increasing speeds without viable alternatives and there is a clear lack of international cooperation on many topics, as evidenced by the Kyoto Protocol not being approved by the United States or Russia as of this writing. The tasks undertaken by the Brundtland commission in 1987 were admirable, but sustainable development still had a long way to go.

In 1989 Karl-Henrik Robert founded The Natural Step as a means of addressing global sustainability concerns. The initial goal of The Natural Step was to define nonnegotiable conditions for human survival and sustainability. Using a systems-based approach to his analysis, Robert teamed with experts around the world and after sending out twenty-one versions of his proposed principles for comment, he built a consensus that defined the requirements for eco-system survival (Ray, 321-322).

The four principles of sustainability as defined by The Natural Step are:

- "To eliminate our contribution to systematic increases in concentrations of substances from the Earth's crust. This means substituting certain minerals that are scarce in nature with others that are more abundant, using all mined materials efficiently, and systematically reducing dependence on fossil fuels.
- To eliminate our contribution to systematic increases in concentrations of substances produced by society. This means systematically substituting certain persistent and unnatural compounds with ones that are normally abundant or break down more easily in nature, and use all substances produced by society efficiently.

- To eliminate our contribution to systematic physical degradation of nature through over-harvesting, depletion, foreign introductions and other forms of modifications. This means drawing resources only from well-managed eco-systems, systematically pursuing the most productive and efficient use both of those resources and land, and exercising caution in all kinds of modifications of nature.
- To contribute as much as we can to the goal of meeting human needs in our society and worldwide, going over and above all the substitution and dematerialization measures taken in meeting the first three objectives. This means using all of our resources efficiently, fairly and responsibly so that the needs of all people on whom we have an impact, and the future needs of people who are not yet born, stand the best chance of being met" (Natural Step).

The Natural Step attempts to remove the ambiguity from "sustainability" and "sustainable development," however while the principles are a scientific consensus developed through cooperation with professionals around the world, they are not universally accepted or practiced, even by those proclaiming to be "sustainable." Courses are being offered in sustainability; institutes for sustainability have been established; business are advertising their products as "sustainable" or "green"; despite the emphasis and growing popularity of sustainability, there is still no definitive determination of exactly what constitutes sustainable practices or how to measure sustainability.

The determination of sustainability can be achieved through the rigorous application of Life Cycle Analysis (LCA) techniques. These techniques identify each process necessary to produce a desired output, analyze the desired and undesired inputs and outputs of each of those processes, evaluate the impact of each of the outputs, and provide feedback for possible process improvement. LCAs are very specific to individual sites and processes – the same process being executed in two different plants could exhibit very different results. While the International Standards Organization is making some movement toward standardizing the LCA process and evaluating materials using LCA principles, the cost and effort necessary to appropriately evaluate using LCA is currently prohibitive.

For purposes of this thesis, sustainability has been evaluated on a relative rather than absolute scale. Consumption of fossil fuels is inherently unsustainable until a viable economic and environmentally sound alternative is developed.[3] However, reducing consumption of energy produced through the combustion of fossil fuels is more sustainable than increasing consumption of energy produced through the combustion of fossil fuels. It is likely that regardless of any efforts taken toward environmental awareness or "clean" technology development we will continue to consume our economically extractable fossil fuel resources until they are gone. Reducing the rate of their consumption mitigates their impact by reducing the immediate environmental threats and provides more time until their depletion in order to bridge the gap to new technologies. While this type of analysis does not provide quantitative data to define

[3] Renewable energy resources such as wind or solar power are generally considered more sustainable than energy production through the combustion of fossil fuels. The relative sustainability of renewable resources depends upon the effort required to implement them and their unintended consequences on the environment.

cohousing as "sustainable" or not, it does provide a qualitative comparison of the relative sustainability of different housing options.

2.2 National Housing Trends

In order to understand cohousing as a living arrangement, it is important to understand the traditional choices that cohousing is substituting for and what the relative impact of those choices are. This section discusses national housing trends and national and regional residential energy consumption in the U.S.

2.2.1 Single-Family Housing Trends

In 2004, the National Association of Home Builders (NAHB) published their "Housing Facts, Figures, and Trends 2004" regarding the housing industry. This section provides a summary of their findings and analysis of these trends.

Since 1980 there have been in excess of 35 million housing starts. Using NAHB estimates for 2003 and 2004, the number is expected o break the 37 million unit mark, for an average of approximately 1.5 million starts per year. (See table 2.1 on the following page.)

The rise in the number of annual starts is notable; however, the percentage of those starts that are single family homes, rather than multifamily dwellings is more astonishing. From 1980 to 1989, there had never been a year when the average number of single-family starts accounted for more than 75% of the total number of starts with the

10-year average being 66%. Since 1990, single-family starts have never accounted for less than 75% of the total number of starts with the average exceeding 80%. So at the same time that more and more homes are being built, an even greater percentage of them are single-family homes as opposed to clustered dwellings (Pflieger, 1). (See Figure 2.1 on the following page.)

Year	Single-Family	Multifamily	Total
1980	852,000	440,000	1,292,000
1981	705,000	379,000	1,084,000
1982	663,000	400,000	1,063,000
1983	1,067,000	635,000	1,702,000
1984	1,084,000	665,000	1,749,000
1985	1,072,000	669,000	1,741,000
1986	1,180,000	626,000	1,806,000
1987	1,146,000	474,000	1,620,000
1988	1,081,000	407,000	1,488,000
1989	1,003,000	373,000	1,376,000
1990	895,000	298,000	1,193,000
1991	840,000	174,000	1,014,000
1992	1,030,000	170,000	1,200,000
1993	1,126,000	162,000	1,288,000
1994	1,198,000	259,000	1,457,000
1995	1,076,000	278,000	1,354,000
1996	1,161,000	316,000	1,477,000
1997	1,134,000	341,000	1,475,000
1998	1,271,000	346,000	1,617,000
1999	1,303,000	339,000	1,642,000
2000	1,231,000	338,000	1,569,000
2001	1,273,000	330,000	1,603,000
2002	1,364,000	347,000	1,711,000
2003 (est)	1,445,000	341,000	1,786,000
2004 (est)	1,381,000	319,000	1,700,000
Total	27,581,000	9,426,000	37,007,000

Table 2.1: Annual Housing Starts in U.S.
Source: NAHB, Housing Facts, Figures, and Trends 2004

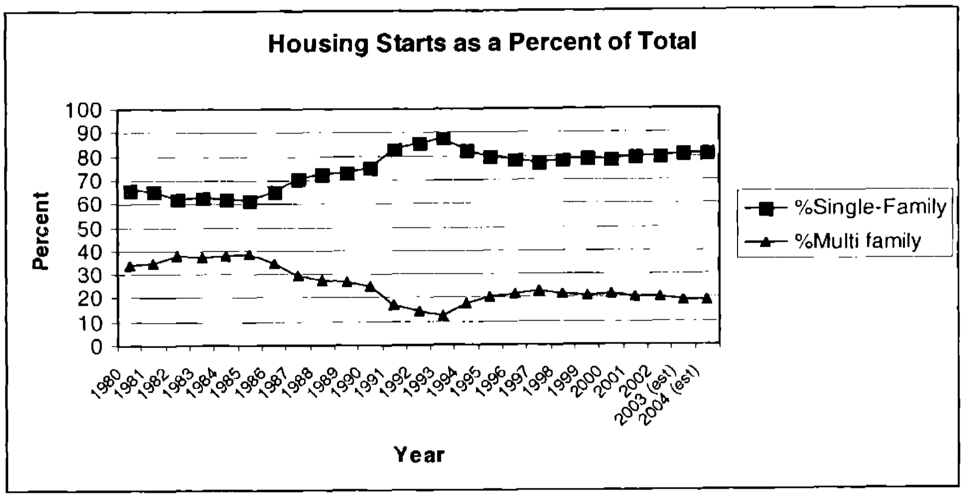


Figure 2.1: Housing Starts as a Percent of Total
Source: NAHB Housing Facts, Figures, and Trends 2004

The NAHB also reports that the finished area of new single-family homes has risen dramatically since 1950. The average home size in 1950 was 983 square feet with 62% of new homes less than 1,200 square feet and a negligible percentage exceeding 2,000 square feet. In 2002 home sizes averaged 2,230 square feet with 5% less than 1,200 square feet and over 50% exceeding 2,000 square feet. What was all but an unthinkable level of comfort in 1950 has become the standard today. (See Table 2.2.)

Finished Area (sq. ft.)	1950	1970	1990	2002
Average	983	1500	2080	2230
Median	1385	1905	2113	2123
Less than 1,200	62%	36%	11%	5%
1,200 - 1,599	19%	28%	22%	19%
1,600 - 1,999	17%*	26%*	22%	21%
2,000-2,399	-	-	17%	18%
Over 2,400	-	10%	29%	37%
*1,600 square feet or more				
**1,600-2,399 square feet				

Table 2.2: Finished Square Feet per New Home
Source: NAHB Housing Facts, Figures, and Trends 2004

When the declining average family size is factored in, the disparity becomes even more obvious. According to the U.S. Census Bureau, the average household size has dropped from 3.37 in 1950 to 2.58 in 2002, a reduction of 23%. As noted above, the average size increased from 983 square feet to 2,230 square feet (an increase of 127%) during the same period of time. The 1950 average space per person was 292 square feet; in 2002 the number had grown to 864 square feet. In the U.S. average living space in new homes per person has nearly tripled in the last half century. (See Table 2.3.) This helps to explain why the energy demand of the built environment has grown substantially over the last few decades (Pflieger, 11).

	1950	1970	1990	2002
Average Area (sq. ft)	983	1500	2080	2230
Average Household Size	3.37	3.14	2.63	2.58
Average Area per Resident	292	478	791	864
Percent Increase since 1950	-	64	171	196

Table 2.3: Average Finished Area per Resident

Source: NAHB Housing Facts, Figures, and Trends 2004

U.S. Census Bureau, Table HH-6, Average Population per Household and Family: 1940 – Present

It is easy to see where the additional space is being built into homes after reviewing NAHB's summary of the desires of the home buyers as determined by their own survey:

- "Buyers of new homes want larger houses with lots of space. They especially prefer large kitchens adjacent to family rooms…
- Nearly 40% of the respondents said they would like a minimum of four bedrooms; 49% would accept three bedrooms. More than a third of new,

single-family homes completed in 2002 had four or more bedrooms, according to the U.S. Commerce Department…

- Regarding extra rooms for convenience and luxury, 92% of respondents wanted a laundry room, 79% wanted a dining room, 58% wanted a home office, 54% wanted a den/library, and 46% wanted a sunroom. Media rooms (28%) and exercise rooms (29%) were not as popular."

The most telling survey result is that "Some of the features that average home buyers want today used to be considered optional and were standard only in upscale luxury homes." Specifically with regard to the desired number of bedrooms assuming an "average household" of three people, and assuming that the parents share a bedroom, nearly a third of all houses being built have two spare bedrooms. Not only does the additional area require the consumption of natural resources to construct, the space is likely conditioned whether it is in use or not and therefore continues to consume resources after construction no matter how sparely it is used.

The respondents were willing to pay for extra bedrooms, larger kitchens, more garage space, and "luxury" rooms. However, the survey indicates that the respondents were only willing to pay a median price of $5,000 up-front in the purchase price of their next home to save $1,000 every year in utility costs. A simple net present value calculation, conservatively assuming a 10-year life of the home and 6% discount rate, indicates that the true value of the estimated savings exceeds $7,000. More realistically assuming a 20-year life and maintaining the 6% rate, the value of the savings more than doubles the value of the proposed initial investment. The rational question to ask is not what a resident is willing to pay to save seven or ten thousand dollars, but whether or not current technology can realize those savings in such a way as to provide an attractive return on the initial investment (Pflieger, 12-13).

Cohousing can meet many of the desires identified in the survey. Dining rooms, sunrooms, libraries, exercise rooms, and even home offices (or those in the common house) are typical in many cohousing developments. However, if the desire is to own the amenities rather than to simply have easy access to them, cohousing may not provide the answers some homeowners are looking for. The desire for extra bedrooms is often addressed with a few extra rooms community wide that are loaned or rented as needed, rather than each home having extra space. Individual kitchens are typically modest, but the community house kitchens tend to rival the size and quality of restaurant kitchens.

2.2.2 Multifamily Housing Trends

The NAHB states "With one in four American households living in multifamily homes, this segment of the marketplace obviously serves an important role in the consumers' housing choices." However, despite the importance of multifamily dwellings, NAHB also reports that these developments "often face negative public perceptions about multifamily housing that are not always based on fact." This perception is not unlike that which cohousing developments may encounter as discussed in Chapter 5.

However, economic concerns are often unfounded as the positive impact on the local economy of multifamily developments can be dramatic and close proximity to multifamily dwellings typically appreciates the value of neighboring houses, not depreciates them. Additionally, multifamily dwelling is inherently more sustainable than single-family homes. They consume fewer natural resources, place lower demand on existing infrastructure and public services (36.7 school-aged children per 100 homes vs. 54.7 for single-family homes), have a lower surface area to volume ratio effectively reducing their energy requirements, consume less water (213 gallons per day vs. 407 for single-family homes), and provide less traffic in a given area than the same number of single-family units would (less than 7 vehicle trips per unit vs. 9.6 for single-family homes) (Pflieger, 16-17).

The average new multifamily unit has 1,011 square feet of space (less than half of that for single-family homes). The growth in the average size is minimal compared to the average growth in single-family homes. (See Table 2.4.)

Square Feet	1971	1980	1990	200	2002
Less than 800	35%	34%	25%	12%	12%
800-999	33%	28%	32%	24%	25%
1,000 or more	33%	38%	44%	60%	63%
Average	1011	979	1005	1039	1165
Median	887	915	955	1060	1069

Table 2.4: Average Size of New Multifamily Homes
Source: NAHB Housing Facts, Figures, and Trends 2004

Additionally, the average household size in multifamily housing is 2.1 for an average of approximately 500 square feet per resident, approximately 60% of the space available to residents in single-family homes. All other things being equal (i.e. construction materials and methods, appropriate siting, sustainable concepts taken into account equally during design), it is easy to see that multifamily dwelling is inherently more sustainable than single-family homes (Pflieger, 15-23).

2.2.3 Green Building Trends

Encouragingly, NAHB includes a section in their report entitled "Building Greener, Building Better, Conserving Resources." The report admits that building green is an inherently local responsibility due to the varying climatic conditions, customs, and local preferences. It also states that green building does not need to be "all or nothing" (incremental changes can make a difference) and that building green does not mean sacrificing comfort, convenience, or style. Norbert Lechner says in his book, "Heating, Cooling, and Lighting: Design Methods for Architects" that, "…Architecture that conserves energy can be comfortable, sustainable, humane, and aesthetically pleasing." One could argue that the fact that the building is sustainable is, in itself, aesthetically pleasing (Lechner, 9).

NAHB points to many sustainable options in construction including appropriate site planning, materials usage, appliance selection, and energy conservation fixtures. It is interesting to note that very few of the suggestions affect the appearance, livability, or durability of the structure. Increased insulation, better underlayments, energy efficient appliances, high grade windows, and low flow toilets all go largely unnoticed except when the energy bill arrives. These features may increase the initial price, but can dramatically reduce the life cycle cost of a home. (Pflieger, 37-39)

2.3 United States National Energy Policy

In the Report of the National Energy Policy Group dated May 2001, President George W. Bush is quoted as saying, "America must have an energy policy that plans for the future, but meets the needs of today. I believe we can develop our natural resources and protect our environment." The report lays out five specific national goals: modernize conservation, modernize energy infrastructure, increase energy supplies, accelerate the protection and improvement of the environment, and increase national energy security. The National Energy Policy Group contends that the "best way of meeting [the modernize conservation] goal is to increase energy efficiency by applying new technology." They further offer policy goals such as review of federal practices, tax subsidies or credit for hybrid and fuel cell automobiles, as well as the development of Combined Heat and Power technology and expansion of the Department of Energy's "Energy Star" efficiency program to include schools, retail buildings, health care facilities, and homes (Cheney, ix). Notably, there is no mention of encouraging consumers to construct and purchase smaller or more clustered homes.

Techniques to improve the efficiency of energy production and reduce demand have already been very effective in mitigating the nation's increase in consumption. The U.S. Department of Energy, Energy Information Administration (EIA), reports that "Improvements in energy efficiency since the 1970s have had a major impact in meeting national energy needs relative to new supply. If the intensity of the U.S. energy use had remained constant since 1972, consumption would have been about 70 quadrillion BTUs (74 percent) higher in 1999 than it actually was" (Cheney, xi).

While this is encouraging news, the Department of Energy estimates that if U.S. consumption and domestic production of oil continues on their current trends the country will have to import 7.5 million more barrels of oil per day in 2020 than they did in 2000. Similarly, if U.S. consumption and domestic production of natural gas continue on their current trends, the annual natural gas shortfall between production and consumption will grow from approximately five trillion cubic feet to more than ten trillion cubic feet (Cheney, x).

If the country is using energy more and more efficiently and has stated goals of continuing that efficiency, then what is driving the consumption increase and what efforts need to be taken to close the projected gap between consumption and production of fuels currently necessary to meet the country's energy needs?

One of the primary drivers leading to an increase in national energy consumption is population growth. The U.S. Census Bureau reports that the 1972 national population was approximately 210 million people. In 2000, the Census Bureau estimated that the 2003 population would be approximately 283 million (increase of 35% over 1972) and 2020 estimates exceed 320 million people (increase of 52% over 1972). Assuming standards of living remain largely unchanged, a growth in population necessitates an increase in energy demand (Population Divison, 1-3).

Another driver is the trend that the luxuries of the few become the needs of the many. As Gregg Easterbrook points out in "The Progress Paradox" what were once unattainable desires for many middle class Americans are now commonplace. He cites Camille Sweeney's research following the 2000 census which reported that of the households earning approximately the median family income, each had recently purchased at least one of the following: a new car, a powerboat, a widescreen television, a vacation cottage, a swimming pool, or an expensive family vacation (Easterbrook, 16). Each of these items theoretically provides an increase in the owner's satisfaction and standard of living, but indisputably results in an increase in energy consumption for that family.[4]

Other trends include increased mobility (194% increase in household vehicle miles of travel between 1969 and 2001, according to the National Highway Travel Survey), larger and more expensive homes (as noted in Section 2.2), and a general desire for convenience as evidenced by increasing electrical consumption of "standby power" (energy consumed when appliances are not in use)[5] (Lebot, 8).

No matter how efficiently electricity is produced or consumed, if the nation's consumption patterns continue to increase, there will be no positive net effect due to increased technology or management practices, exacerbating the issues that have led us to this energy crisis in the first place. It is necessary to change consumption habits in order to fully realize the impact of improved production and efficient consumption.

2.4 Factors Affecting Carbon Emissions

As noted in section 2.1, the United States has not ratified the Kyoto Protocol for a variety of reasons that will not be discussed in depth here. Suffice to say that while it is imperative that the U.S. and other nations around the globe significantly reduce their

[4] The possible exception is the new car, which could likely be more efficient than the car that it replaced. The National Energy Policy Report states that automobiles today use 60% of the gasoline consumed in 1972.

[5] A study by Lebot, Benoit, Alan Meier & Alain Anglade, "Global Implications of Standby Power Use", indicates that 5% of U.S. residential power is consumed by appliances in standby mode, resulting in an estimated 28.7 MTons of CO_2 emissions.

carbon dioxide emissions, Kyoto does not provide a framework for that reduction that is palatable to the U.S.

Japanese engineering professor Yoichi Kaya developed an identity to provide an indication of what factors could be adjusted to mitigate carbon dioxide emissions, and how difficult that mitigation would be. Professor Kaya defined these factors as fossil fuel use (C), energy produced (E), economic output (Y), and population (P). These factors were used to create an identity which would allow the impact on overall fossil fuel use (and therefore carbon dioxide emissions) to be estimated based on changes to the other factors.

$$C = (C/E) * (E/Y) * (Y/P) * (P)$$

(C/E) indicates the amount of fossil fuels to achieve a given amount of energy production. If nuclear, wind, or solar power is used for energy production then the amount of energy increases without increasing the use of fossil fuel and the ratio is reduced.

(E/Y) indicates the amount of energy necessary to achieve a given economic output (or standard of living). If a large amount of energy is required to achieve a certain economic standard, this ratio is large, while if a given economic output can be achieved with less energy then the ratio is smaller.

(Y/P) is the amount of economic output per person. Large gross domestic products distributed over large populations are considered equivalent to smaller gross domestic products over similarly smaller populations (Deutch, 91).

In effect, this identity states that in order for a given nation to reduce its carbon dioxide emissions it can incorporate non-fossil fuel based energy sources, find less energy intensive means to achieve the same economic standard, accept a lower standard of living for the population, or incentivize a smaller population. Some of these options are not terribly attractive. Non-fossil fuel based energy sources are not as economically viable, reliable, or flexible as fossil fuel sources. Accepting a lower standard of living is neither a choice most people will voluntarily make, nor does suggesting that they do typically make for a long political career. However, given current economic models even sustaining the standard of living is not enough; growth is assumed to be necessary to achieve and maintain a thriving economy. While the U.S. population can be controlled, the most effective way to do so would be to close the borders since most of the nation's growth is attributable to immigration. Again, that choice is neither palatable to most people nor politically expedient.

It appears that the factor which could be affected most readily and with the minimum impact on the standard of living is the energy intensity needed to achieve a given economic standard. This could be achieved through stricter fuel efficiency standards for vehicles, more attention to energy consumption in buildings, expanded use of energy efficient appliances, lights, and entertainment devices, and by taxing energy consumption, which would encourage all consumers to find the most efficient means to achieve their goals.

There is no "silver bullet" which can reduce fossil fuel energy consumption, and therefore carbon dioxide emissions. A systems thinking approach must be taken in which all effectible aspects of the problem are addressed in order to achieve the required reduction. Each policy proposal must account for the Kaya Identity and realize that changing any one of the factors necessitates a (potentially undesirable) change to one of the others.

2.5 Summary

Despite the fact that modern western lifestyle is commonly accepted as unsustainable in the scientific community, and despite the risk associated with continuing on our current consumption trends, there is little promise in reversing those trends anytime soon. As consumers we continue to purchase homes of increasing size as well as exhibit growth in other consumption habits; as a nation we have an energy policy that states that we are in the "most serious energy shortage since the oil embargoes in the 1970s" (Cheney, viii) yet does nothing to address the primary driver in that shortage which is American consumption habits; as a scientific community we have an irrefutable proof indicating what steps need to be taken to reduce global concentrations of carbon in the atmosphere yet we are unwilling or unable to make the hard decisions in order to effect change.

While the concepts of cohousing and global warming are not apparently linked at first sight, the housing market is a prime contributor to energy consumption trends in the U.S. If the nation is to get serious about reducing our contribution to global warming, each potential impact must be analyzed so that the most appropriate housing choices can be made. Can cohousing be an appropriate housing choice to reduce personal energy consumption, reduce the nation's consumption of fossil fuels, and contribute to a reduction in atmospheric concentrations of greenhouse gasses? The rest of this thesis answers that question. Chapter 3 outlines the choices in development and construction of two communities, analyzes them and determines their impact. As noted in Chapter 1, cohousing infrastructure differs significantly from the infrastructure associated with other living arrangements, but the relative impact of that infrastructure was largely unknown. Once the answers to these questions are known, the value of cohousing, and its relative sustainability and environmental impact, can be determined. With that information, governments, policy makers, and consumers can make informed decisions regarding their housing options.

CHAPTER 3

CASE STUDIES

To assess the potential energy savings of cohousing developments, case studies were performed on EcoVillage at Ithaca (EVI) and Cambridge Cohousing. These two communities were chosen as much for their differences as their similarities. EVI is a semi-rural community that developed a green-field site; Cambridge Cohousing was an urban infill project on a former industrial site. EVI currently has two neighborhoods, each with 15 duplexes, and one completed common house. The neighborhoods are each clustered on just a few acres. Cambridge Cohousing combines all of the homes and common facilities into one large structure. Each of these differences could provide for different energy consumption needs and trends, affecting the surrounding solar, wind, and thermal conditions as well as the overall energy efficiency of the community. Both EVI and Cambridge Cohousing were selected because they included design characteristics that were used to consciously decrease energy consumption. The communities are also in the same geographical census region (i.e. Northeast) which allows for regional comparisons. The two communities are in different climatic regions (based on 30-year heating degree day averages[6]), but are relatively similar climatically and provide a reasonable basis for comparison.

3.1 EcoVillage at Ithaca

The founder of EcoVillage at Ithaca, Joan Bokaer, got the idea for the community while leading a walk across the United States in 1990. "When you walk across the country, you see the destruction caused by the way we've developed our cities," (Aeppel, B9). While many cohousing communities are environmentally aware, few place the emphasis on ecological sustainability that EcoVillage at Ithaca does. From initial conception, through their early planning stages in 1992 and 1993, to today, the community places a constant emphasis on sustainability. A demographic survey performed in April 2002 indicates that 18% of the residents chose EVI for the ecologically sustainable aspects, while 32% chose EVI for the community aspects, and 44% chose EVI for both equally.

A review of their Guidelines for Development provides some insight into their priorities. Below are goals from the guidelines which indicate their commitment to sustainability:

- To establish a sustainable relationship between human habitation on the land and the living matrix of plant and animal life.

[6] Heating degree days are a measure of the total amount of time that heating is necessary to provide comfort. One degree below the baseline comfort temperature (65 degrees Fahrenheit for this analysis) for 24 hours is one heating degree day. Alternatively, 24 degrees below the baseline comfort temperature for one hour is also a heating degree day.

- To encourage pedestrian and bicycle circulation, and to restrict vehicle access into residential areas.
- To maximize open space.
- To reduce vehicle traffic by establishing an on-site commercial center.
- To develop on-site employment opportunities for village residents.
- To serve as a focal point for teaching about sustainability in all its aspects.
- To support research activities such as permaculture applications, aquaculture, bioshelter design, building materials, etc.
- To produce a substantial part of the food for EcoVillage on-site.
- To develop, demonstrate, and teach sustainable technologies and methods including organic farming, minimal use of fossil fuels, and build long term fertility.
- To foster native natural systems and species.
- To preserve, restore, and create natural areas to the greatest extent practical including wetlands and woods.
- To foster non-human life and diversity.
- To minimize water use through strict conservation practices, allowing water to be supplied in sustainable quantities (Guidelines for Development, 1-7).

The list of sustainable goals and objectives goes on. From these excerpts it is obvious that sustainability was a priority of the village since its inception.

The first neighborhood group, called FROG, began occupying their homes in 1997. The second neighborhood group, called SONG, completed construction of their residences in 2003 and have moved in. The SONG common house is still incomplete and residents are using the FROG common house. Due to the relatively developed information for FROG and the relatively new disposition of SONG, all data being reported here is for FROG unless otherwise noted. An aerial view of the community from May 2003 is shown below (Picture 3.1). The neighborhood on the right is FROG, and SONG is on the left.

Picture 3.1: Aerial Photo of EVI
Source: http://www.ecovillage.ithaca.ny.us/evi_gallery.html

3.1.1 Impact of Development

While the community's two primary emphases were sustainability and community development, they had to balance those priorities with affordability and availability of current technologies. While some residents wanted "state-of-the-art equipment, such as windmills and solar collectors to generate all the development's electricity" (Aeppel, B9), those technologies are currently not as adaptable or affordable as energy production from fossil fuels. As a result, EVI made compromises during the original design and construction which allowed them to develop the community affordably, but allow for future use of more renewable energy resources.

3.1.2 Planning

EVI is situated on 176 acres west of Ithaca, New York. The community purchased the acreage for $400,000 from a developer that had been planning a traditional subdivision. According to information provided by EVI Director, Liz Walker, the original owner's plan was to provide 150 single-family homes on approximately 1 acre lots. The EVI site plan calls for up to five neighborhoods of approximately 30 units each to be clustered on no more than two and a half to three and a half acres per neighborhood (including the common houses and buffer areas). The original developer would have developed nearly all of the 176 acres while the EVI plan, if fully implemented, will provide the same number of homes on one-tenth of the developed acreage. EVI's website (http://www.ecovillage.ithaca.ny.us/) indicates that they are committed to preserving 80% of the land as green space, and 55 acres have already been "permanently preserved through a conservation easement managed by the Finger Lakes Land Trust."

EVI is located two miles from downtown Ithaca and is served by the municipal bus service. This location does provide a minimal commute for most of the residents but it also created the additional impact of requiring roadways and utilities being extended to the community. Infrastructure extension is one of the inherent complications to sustainability in rural or suburban developments. Urban living does have the advantage of already developed infrastructure and, therefore, the marginal impact of a new development may be small compared to rural or suburban developments.

3.1.3 Siting

House Craft Builders of Ithaca was hired as the planner and architect for the project. Additionally, they served as project manager during the construction. Their schematic designs indicate the issues taken into consideration when siting the individual units. The schematic begins, "The EcoVillage Cohousing Coop is designed to combine community living with individuality and energy efficiency within a model of planning which minimizes negative impacts of housing on the earth." In order to achieve this goal, the houses were designed as duplexes clustered in groups of 3 or 4, with each group served by a central energy center. Duplexes are inherently more energy efficient than individual structures because of the shared wall and a reduced surface area to volume ratio. The central energy center was also intended to provide economies of scale and greater efficiency in providing energy to the units.

Additionally, each house has a 14' window wall facing south which provides natural light and solar gain in the winter. Trellises are provided to minimize the solar gain in the summer. The layout of the buildings is such that each unit has exposure to the southern sky and most of the roofs are angled in such a fashion that they lend themselves to future installation of solar panels (Schematic Design, 1-2).

3.1.4 Construction

The homes range from one-bedroom units with approximately 900 square feet of livable space to four bedroom units with just over 1,700 square feet of livable space with an average size of 1,228 square feet. As noted in Table 2.2, the average new single-family home size in the United States in 2001 was 2,230 square feet. The residents at EVI get by with less individual space due to personal choice, available common house facilities (which when included increase the average size per home to 1345 square feet) and architectural attention to detail. The architect states in the schematic design that the "footprint of the houses are highly space-efficient, thereby covering less land area."

Additional efforts to reduce the environmental impact include:

- Each house is super-insulated, with double-wall, air-tight construction providing 6-7" of dense packed cellulose which allows for electrical and plumbing runs to be completely enclosed within the insulation. This super-insulation is intended to provide year-round comfort with a minimal reliance on mechanical heating and cooling systems.
- All of the windows are triple-paned glass which reduces interior heat loss in the winter while allowing for exterior solar heat gain.
- The homes are equipped with dual drain piping to allow for future implementation of a grey water system. For the short-term this will increase the embodied energy, but the community expects that if the grey water system works properly the savings should justify the redundancy.
- Centralized laundry facilities and reduced need for large individual stoves, refrigerators, etc. due to common house resources.

3.1.5 Energy Consumption

Jay Jacobson of EVI has been tracking electrical and natural gas consumption since 1997. Table 3.1 summarizes his data on the following page:

Year	Natural Gas (therms)	Electricity (kWh)
1997	17,155	116,163
1998	17,520	120,450
1999	15,427	143,569
2000	16,398	128,629
2001	15,390	119,191
2002	15,930	118,340
Annual Avg.	16,303	124,390

Table 3.1: EVI Energy Consumptions

Source: Correspondence with Resident Jay Jacobson

Natural Gas is used for hot water and space heating in 30 homes and Common House

Electricity is used in homes, Common House, energy centers, shop, and pumphouse

The average annual consumption has been further divided by both the square footage and the total number of residents (as reported in the April 2002 Demographic Survey).

Average Annual Consumption	Natural Gas (therms)	Electricity (kWh)
Per Household	543	4146
Per Square Foot	0.40	3.08
Per Resident	204	1555

Table 3.2: EVI Consumption Averages

These results can be converted to the common unit of British Thermal Units[7] (BTU) for comparison with regional and national averages.[8] Figure 3.1 indicates the average energy consumption at EVI per household, square foot, and resident.

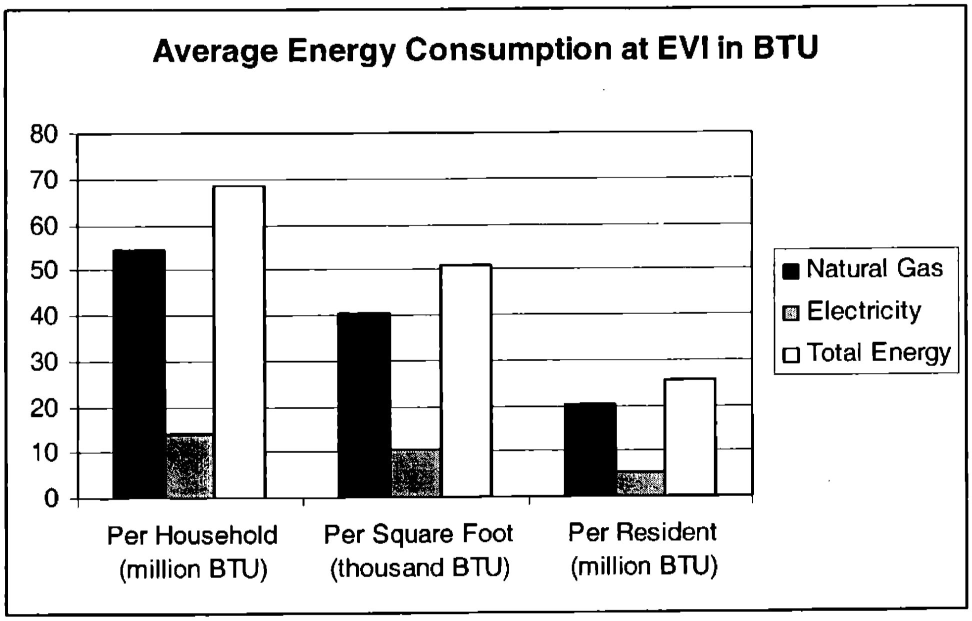


Figure 3.1: Average Energy Consumption at EVI in BTU

3.2 Cambridge Cohousing

Cambridge Cohousing is located at 175 Richdale Avenue, Cambridge, Massachusetts near the Porter Square neighborhood. In 1996, the community purchased the property from Richdale Realty Trust (which has developed neighboring condominiums) and began construction of their community soon after, on their way to becoming the first urban cohousing development in the eastern United States. Today 41

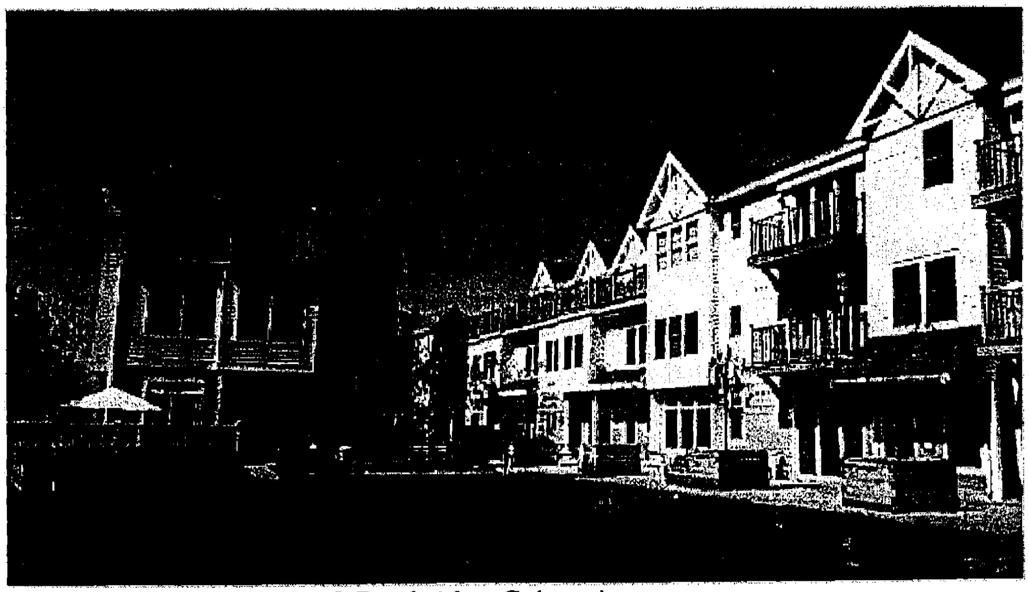
[7] A British Thermal Unit is the amount of thermal energy needed to raise the temperature of one pound of water one degree Fahrenheit.
[8] One therm is equivalent to 99,976 BTU; one kilowatt-hour is equivalent to 3412 BTU.

households with 95 full or part-time residents live in the community. Cambridge Cohousing is legally organized as a condominium association, with their bylaws written in such a way that they lend themselves to the cohousing principles of resident management and consensus decision making.

While both EVI and Cambridge Cohousing model themselves closely after the McCamant and Durrett cohousing model, EVI's ecological focus is more strongly stated and the scope of their sustainable efforts are more varied and more emphasized. This is not to say that the residents of Cambridge Cohousing are not environmentally aware or that they do not consider themselves to be living more sustainably than the population as a whole. Three of their six goals for the condominium association point to their concern for sustainable development:

- To create an environment that embodies principles of quality, simplicity and beauty;
- To emphasize conservation, recycling, non-polluting energy sources, sharing of resources and other environmentally sound practices;
- To provide open space for play, food-growing, beauty and tranquility.

Cambridge Cohousing has been occupied since late 1998. The data being used for this analysis is natural gas and electricity data provided from 1999 to 2003. A site photo of the development is shown on the following page (Picture 3.2).



Picture 3.2: Site Photo of Cambridge Cohousing
Source: http://www.cambridgecohousing.org/photos.html

3.2.1 Impact of Development

The community differs significantly from EcoVillage at Ithaca. The most obvious difference is that Cambridge Cohousing is located near a city center, with a 10 minute walk to the nearest public transit, while EVI is located in a semi-rural environment separate from Ithaca. The former industrial site represents excellent use of urban infill concepts which minimize the impact on the local infrastructure and preserve open spaces in other areas. Cambridge Cohousing has 41 households located on a one and a half acre site (as opposed to EVI's 30 units on 3 developed acres, or planned 150 units on 15 developed acres and 176 total acres). The urban environment forced Cambridge Cohousing to make design and construction choices that would not have necessarily been made at more rural sites.

3.2.2 Planning

Cambridge Cohousing took advantage of the built urban environment surrounding them, including existing utilities, roadways, and access to public transportation. These factors significantly reduce a development's marginal impact over that of a community which needs to construct new or extend existing infrastructure. While their population density is not nearly as dense as high-rise apartment, it is relatively dense considering their surrounding area (primarily condominiums, single-family homes, and duplexes) and desire for green space to complement their built environment. In addition to their buildings, they have a very large courtyard used for play, relaxation, and socializing. Being located near public transportation has obvious benefits, and the primary drawback of noise pollution is mitigated by the window selection on the northern face of the development.

3.2.3 Siting

Because the Cambridge development was located in an urban environment there were various issues to take into consideration. By orienting the community to the south, the community was able to locate their courtyard and entrances on a low traffic volume street, reducing the noise and traffic that would impact the courtyard (and at least moderately off-setting the noise from the trains), and take full advantage of solar exposure. Most of the parking is underground, reducing the impact of extended land use.

Additionally, each of the community's buildings is joined to adjacent structures. The massing of the buildings results in joined walls and a significant reduction in surface area to volume area ratio when compared to duplexes or single-family homes. This configuration also further reduces the impact of land use and allows the community to preserve a sizeable area for its courtyard (Tarnay, 1-4).

3.2.4 Construction

The homes range in size from approximately 600 square feet to over 2,500 square feet, when all conditioned spaces (including basements and storage space) are taken into account. The average home size is about 1,500 square feet before common facilities are allocated and approximately 1,800 square feet when all conditioned spaces are considered and averaged among the homes. While these homes sizes are larger than EVI's and larger than the national average for new multi-family homes, they are approximately 15% smaller than the typical new single-family homes.

In order to expedite construction, reduce costs, and minimize the embodied energy, environmental impact, and waste of the typical construction process, Cambridge Cohousing elected to purchase modular homes, manufactured in a controlled environment, and assembled onsite. The homes were constructed with 2 x 6 framing in the walls using R-19 insulation, with R-38 insulation in the top floor and blown in cellulose between the bottom floors and unconditioned spaces beneath.

In addition to walls thicker than typical construction (most new construction uses 2 x 4 framing), other efforts to increase the energy efficiency of the community included:

- High efficiency windows providing R-3 insulation value as opposed to R-1 values for single pane windows;
- Cellulose insulation blown into the building's perimeter, where significant heat loss occurs;
- Centralized heating, cooling, and hot water production to provide economies of scale and make investments in newer technology possible;
- Ground-source heat pumps in order to provide heating and cooling[9];
- High efficiency appliance and fixtures.

According to Robert Cowherd, an architect and resident of Cambridge Cohousing, the community had a variety of quality issues discovered both during and after construction. Significant portions of insulation were found to be missing; the ground source heat pumps intermittently failed and had to be replaced resulting in significant cost increases and presumably increased energy consumption; flashing was improperly installed in various locations resulting in leakage and in significant replacement costs. Cambridge Cohousing is currently pursuing resolution of these matters. Their impact to the cost and energy efficiency of the project is detrimental, and pending satisfactory resolution of each of the issues, the lifetime averages may decrease. For these purposes, the data will be analyzed as provided with the understanding that had the quality control and project management of the development been more exacting, that these numbers may have been reduced.

[9] Ground-source heat pumps extract groundwater from the surrounding area and utilize it as the medium for heating and cooling. Since groundwater is cooler than the surrounding air in the summer, and warmer in the winter, the heat cycle is more efficient that using outside air as the medium for heat transfer.

3.2.5 Energy Consumption

Based on information received from Robert Cowherd, Cambridge Cohousing resident, the following energy consumption data were calculated:

Year	Natural Gas (therms)	Electricity (kWh)
1999	10,773	559,686
2000	8,566	544,800
2001	8,572	555,680
2002	15,557	441,659
2003	19,114	440,096
Annual Avg.	12,516	508,384

Table 3.3: Cambridge Cohousing Energy Consumption
Source: Correspondence with resident Robert Cowherd[10]

The average annual consumption has been further divided by both the square footage and the total number of residents (as indicated by construction drawings and Robert Cowherd):

Average Annual Consumption	Natural Gas (therms)	Electricity (kWh
Per Household	305	12400
Per Square Foot	0.17	6.87
Per Resident	138	5,587

Table 3.4: Cambridge Cohousing Energy Consumption Averages

Similar to the energy analysis performed for EVI, these averages are

[10] Natural Gas was initially used for hot water and the common house stove; in Jan. 2001, the heat pumps were no longer used for heating and natural gas heat was provided; heat pumps still provide cooling Electricity is used in homes, common house, and for the ground source heat pumps; due to missing insulation some homes purchased electric space heaters.

converted to BTU and presented in Figure 3.2 on the following page.

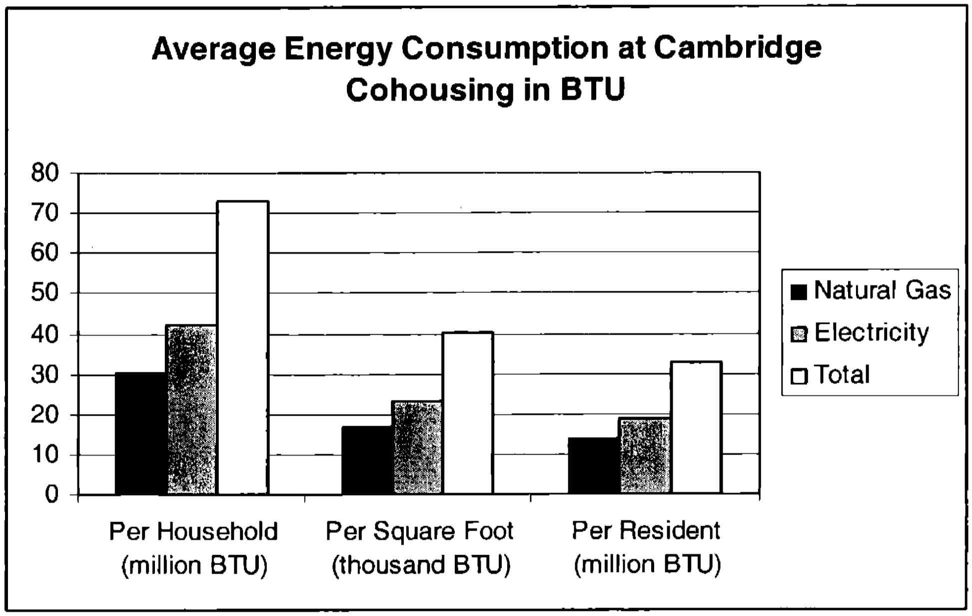


Figure 3.2: Average Energy Consumption at Cambridge Cohousing in BTU

3.3 National/Regional Averages

The U.S. Department of Energy, Energy Information Administration (EIA) publishes annual reports regarding energy consumption trends in the country. Table CE1-1c of their 2001 annual report provides information related to consumption in varying climatic zones based on heating degree days (HDD). Table CE1-9c of the same report provides information related to consumption in the Northeast Census Region (where both Ithaca, New York, and Cambridge, Massachusetts are located). A summary of these results are provided in Table 3.7 on the following page.[11] It is interesting to note

[11] Primary electricity and wood are neglected in EIA's tables and have been excluded here as well. Primary electricity is a function of the generation, transportation, and distribution process, not the efficiency of the home. Wood consumption is difficult to estimate and provides only a marginal contribution to the total.

that households in the warmer climate of 5,500 – 7,000 HDD consume more energy per household than those in the climates with greater than 7,000 HDD. This is due to an increased demand for energy for cooling in the summer. Climates with fewer HDD typically have more cooling degree days (CDD). Or it may simply be that the warmer climatic region has larger houses or more amenities which lead to increased consumption (Latta).

	United States Total	>7,000 HDD	5,500 to 7,000 HDD	Northeast Region
Total Number of Households (millions)	107.0	9.2	28.6	20.3
BTUs (quadrillions)				
Site Electricity	3.87	0.30	0.88	0.52
Natural Gas	4.84	0.43	1.99	0.98
Fuel Oil	0.71	0.17	0.26	0.58
Kerosene	0.05	0.01	0.01	0.02
LPG	0.37	0.07	0.11	0.05
Total BTUs (quadrillions)	9.84	0.98	3.25	2.15
Total BTUs/Household (millions)	92.0	106.5	113.6	105.9

Table 3.5: Total Energy Consumption in the U.S. (excludes wood and primary electricity)

Source: 2001 Consumption and Expenditure Tables, U.S. DOE, EIA, Table CE1-1c and Table CE1-9c

The U.S. Census Bureau, American Housing Survey Branch reports in their report "American Housing Survey for the United States: 2001" that the median size of existing housing stock is 1,736 square feet. For purposes of this thesis, the median is considered the national average and is also considered the average for each of the specific regions being analyzed. As noted in Chapter 2, the current household size in the U.S. is approximately 2.58 residents per household. Using these data, the average energy consumption per household, per resident, and per square foot is calculated for each region. The results are provided in Figure 3.3.

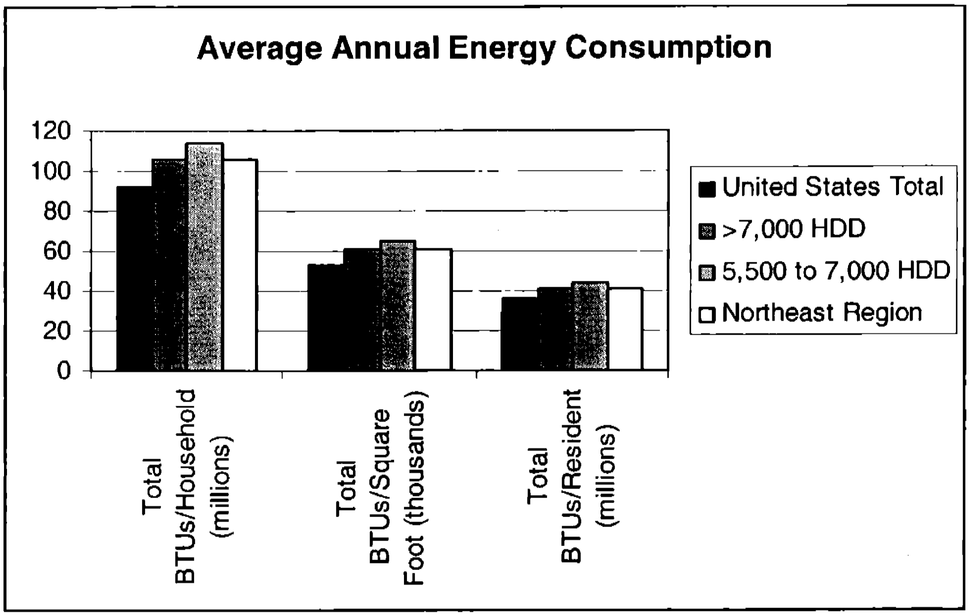


Figure 3.3: Average Annual Energy Consumption

Now that the energy consumption data from EcoVillage at Ithaca and Cambridge Cohousing have been normalized with the data from the national, regional, and climatic averages comparisons can be made regarding the relative energy consumption of each population. Chapter 4 provides this comparison and draws conclusions regarding the environmental impact of cohousing the viability of implementing cohousing or cohousing principles on a broad enough scale to impact national trends.

CHAPTER 4

DISCUSSION

4.1 Analysis of EcoVillage at Ithaca

Figure 4.1 provides a comparative analysis of EcoVillage at Ithaca to population averages.

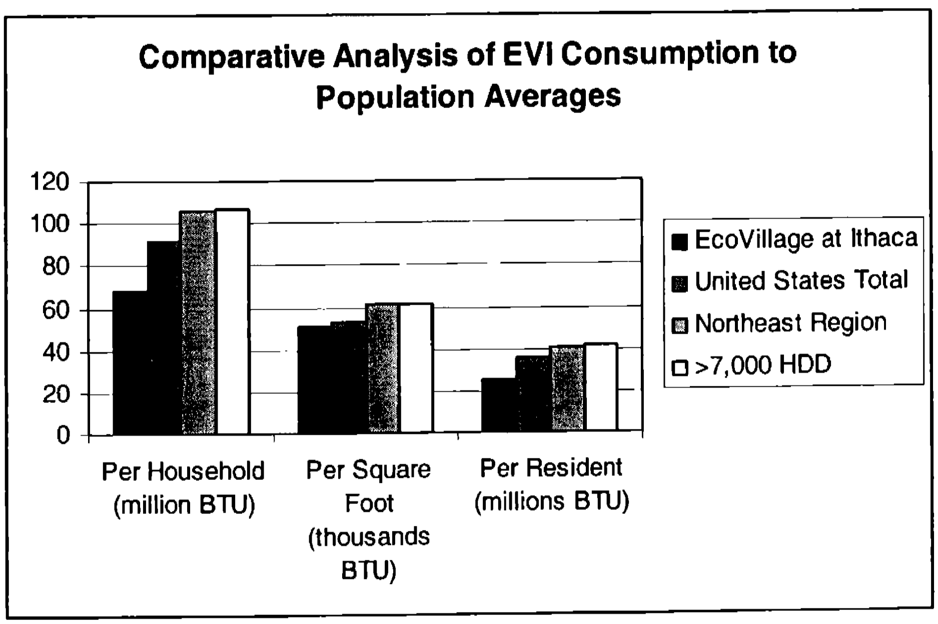


Figure 4.1: Comparative Analysis of EVI Consumption to Population Averages

Comparing energy consumption on a square foot basis provides an indication of the quality of the construction and the effectiveness of energy efficient building materials and practices. While there are factors aside from the design and construction that could affect this metric (e.g. personal consumption habits of the residents) in general it provides the best indication of the quality of planning and construction. Comparing consumption based on the number of residents indicates the effectiveness with which the space is being used. For example, a few people living in a large and well constructed conditioned space may exhibit a low energy consumption per square foot, but it would not provide a rational comparison of how fully the space is being occupied. Alternatively many people living in a relatively small and energy inefficient structure, may be consuming less per resident that those in the large, well-constructed building. Comparing household consumption averages incorporates both of those issues and provides an overall measure of the energy efficiency of a given housing arrangement. It combines the built infrastructure with space utilization and also incorporates the personal consumption habits of residents. Each of the metrics is important as they each provide an indication of the three drivers in household energy consumption: construction and planning techniques and quality, space per resident, and energy consumption habits of the residents. None of them provide a definitive determination of sustainability or quality of life, but when all three are considered, determinations can be made regarding the effectiveness of individual aspects of a housing choice.

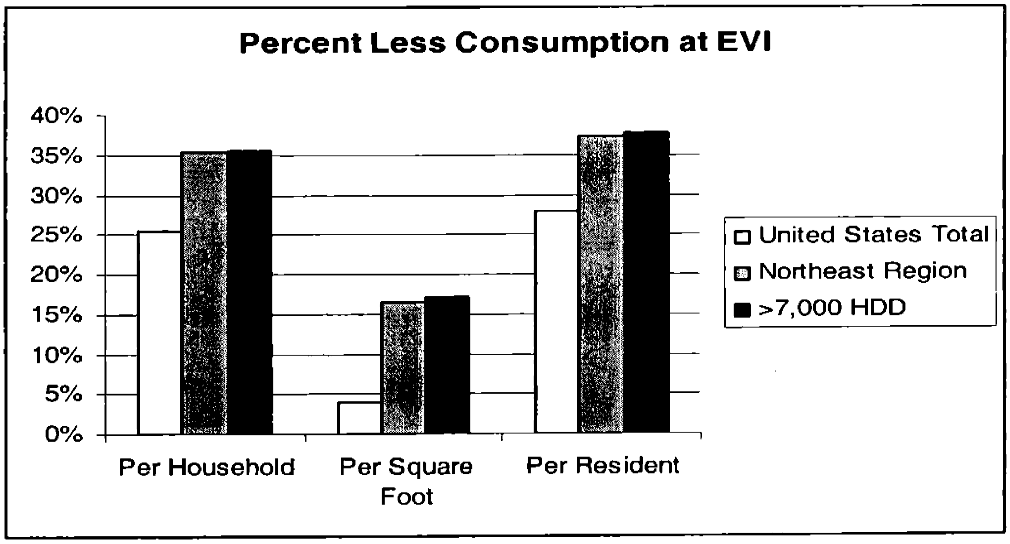


Figure 4.2: Percent Less Consumption at EVI than Population Averages

Figure 4.2 indicates the energy savings of EVI over the population averages. It is apparent that the built infrastructure at EVI surpasses that which is typically constructed due to energy savings in excess of 15% over the Northeast and similar climatic regions when compared on a square foot basis. While the savings are less when compared to the national average, one must recognize that much more temperate climates contribute to the national average than that found in Ithaca, New York.

The data also shows that EVI is efficiently using its resources with regard to the number of residents being housed. EVI is experiencing energy savings in excess of 35% per resident when compared to the Northeast and similar climatic regions, and is again more efficient than the national average, by approximately 25%, while experiencing a harsher climate. This is primarily driven by the space per resident (504 square feet per person at EVI versus an estimated 670 for existing home stock and 864 square feet per person for new single-family homes). Building smaller homes and sharing common areas works to reduce per resident energy consumption.

When these factors are combined and compared as a household average, EVI consumes approximately 35% less energy than the Northeast and similar climatic regions, and approximately 25% less than the national average.

4.2 Analysis of Cambridge Cohousing

Figure 4.3 provides a comparison of Cambridge Cohousing energy consumption to the national and pertinent regional averages.

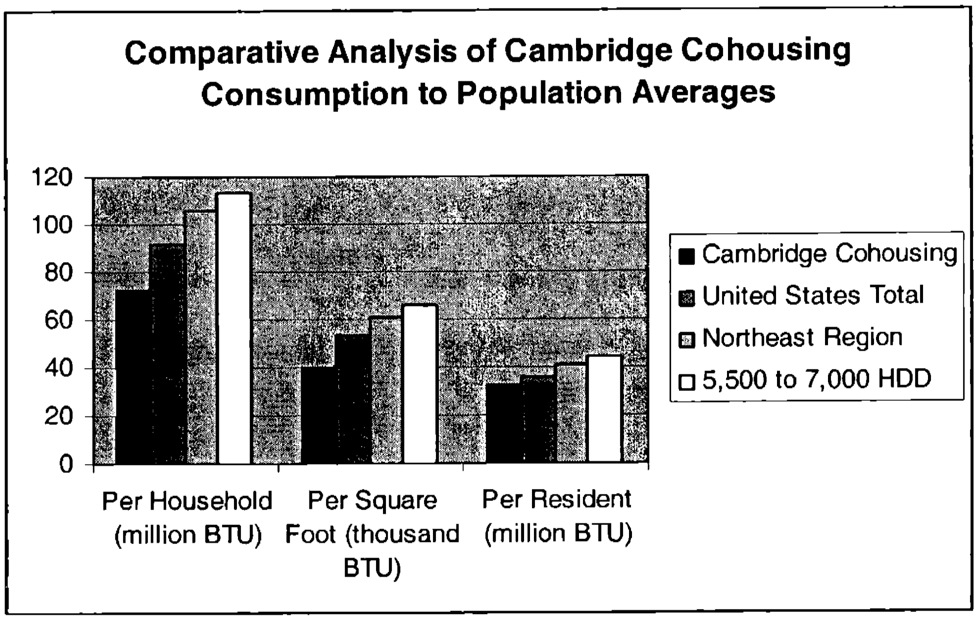


Figure 4.3: Comparative Analysis of Cambridge Cohousing Consumption to Population Averages

Figure 4.4 indicates the energy savings at Cambridge Cohousing when compared to the population averages.

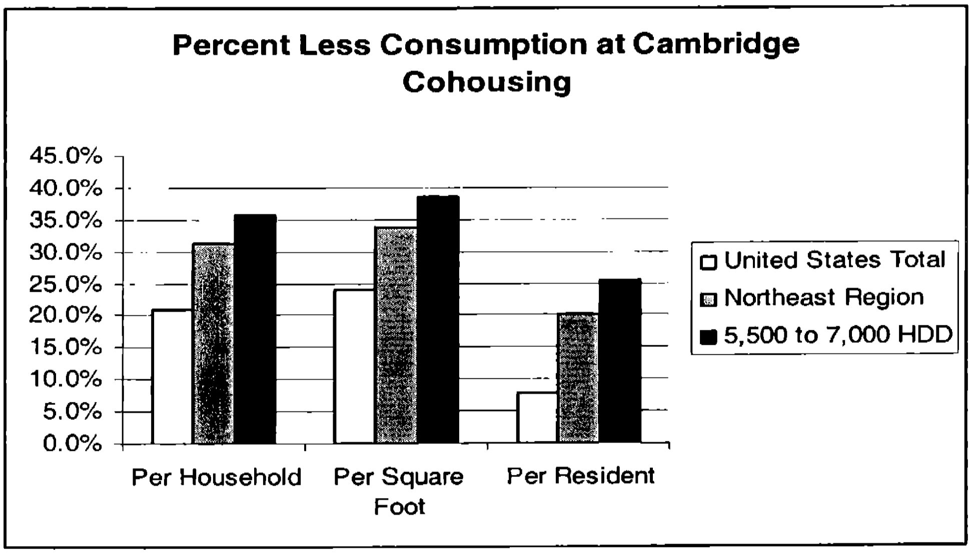


Figure 4.4: Percent Less Consumption at Cambridge Cohousing than Population Averages

As with EVI, Cambridge Cohousing exhibits significant efficiencies over the population averages, in fact Cambridge Cohousing's infrastructure is significantly more efficient than population averages and more efficient than EVI when compared on a square foot basis. This is likely due to the clustered nature of the development (versus close but separate duplexes at EVI, and the dominance of single-family homes for the population) and is an indication that the thicker walls, extra insulation, high-quality windows, and centralized mechanical systems provide for significant efficiencies.

Cambridge Cohousing is also more efficient than population averages with regard to consumption per resident, but not as efficient at EVI by the same measure. Again, this is largely driven by the comparative area per resident but is also affected by other energy efficiency efforts. Cambridge Cohousing has 813 square feet per person, significantly more than EVI and the national average of existing home stock, but still lower than new single-family homes.

When energy consumption per household is considered, Cambridge Cohousing exhibits savings of 25-35% over relevant population averages. It is apparent that cohousing when combined with environmental awareness and social consciousness can, and does, provide for significant opportunities to save energy.

4.3 Potential Economic Savings

EIA reports that the 2002 monthly residential average for one thousand cubic feet of natural gas was slightly more than thirteen dollars, or approximately $13 dollars per million BTU (MBTU), and that electricity in the Northeast Region cost approximately twelve cents per kilowatt hour, or approximately $35 dollars per MBTU.[12] EIA's latest estimates (1997) for the total household expenditures for energy in the Northeast region are approximately $1,600/household (Latta).

EVI consumes approximately 68.5 MBTU per household, 54.3 for natural gas and 14.1 for electricity. The estimated cost of this energy is approximately $1,200/household, a savings of about $400 per year when compared to the 1997 Northeastern average, with greater savings being realized when inflation from 1997 to the present is considered. Assuming a 20-year life of the buildings, a six percent discount rate, and relatively stable energy prices this amounts to over $4,500 in net present value to the building owner.

Cambridge Cohousing consumes approximately 72.8 MBTU per household, 30.5 for natural gas and 42.3 for electricity. The estimated cost of this energy is

[12] Electricity is so much more expensive because, unlike natural gas, it is not a primary fuel. The additional cost of converting from the primary source of power (typically a fossil fuel) to electricity as well as the higher demand for energy that is as reliable, flexible, and convenient as electricity makes it a significantly more expensive energy source than natural gas, fuel oil, or other primary energy source.

approximately $1,877 per year. Despite consuming less energy than the Northeastern average, Cambridge Cohousing is paying about the same in real time dollars. This is due to their reliance on electrical energy which comes at a premium price and has inherent inefficiencies in production, transportation, and distribution. Electrical production plants using natural gas as their primary fuel source operate at approximately 45% efficiency (i.e. 45% of the chemical energy in the fuel is produced as electricity) (Deutsch 169). Furthermore, approximately one-fourth of the electricity generated is used at the site by the residents. The rest is consumed in the primary electrical system which is responsible for the transportation and distribution of the electricity to consumers (Latta). In effect, approximately 10% of the chemical energy available in natural gas is available for use when it is first transformed into electrical energy and transmitted via the primary power grid. While Cambridge Cohousing's housing arrangement is efficient onsite, due to the inefficient means by which they procure their energy they are not realizing the full economic benefit of their choices.

4.4 Potential Impacts to Nationwide Consumption Trends

It is intuitive, if not obvious, to say that building smaller, better constructed homes, out of higher quality materials with an emphasis on reduced energy consumption will result in less energy consumption per household than what has become typical construction in this country. While that is true, it is important to know that there are communities where this blueprint for reduced energy consumption is being followed successfully and to investigate those communities to determine which aspects of their housing choices can be transferred to others who may not choose to live in the cohousing model.

Cohousing does not currently appear to be scalable. That is, there are few (if any) economies of scale in developing larger communities, or attempting to develop more than one community at a time. To date, those communities that have been led by developers, as opposed to developers being hired to advise the residents, have been less successful (in terms of developing community and popularity of the units) than communities where the McCamant and Durrant model was followed. Until developers, municipalities, and financiers develop standard operating procedures to shorten the amount of time it takes for a community to develop, obviating the need for special considerations or waivers on every community, it is unlikely that cohousing residents will ever represent a large enough percentage of the population in order to affect national energy consumption trends. However, if business, financial, and governmental agencies can streamline their processes to support cohousing, some of the inherent difficulty in recruiting and retaining members may be reduced. This would effectively reduce the amount of time it takes for a community to go from inception to occupation.

4.4.1 Housing Stock Turnover

According to figures presented by the National Association of House Builders, since 1980 there has been an average of approximately 1.1% exponential growth rate in the number on new homes being constructed. Assuming that growth rate will continue until the year 2020, when the nation's population is estimated to be approximately 325 million residents, there will be approximately 36 million new housing starts between the years 2001 and 2020. Further assuming that the average household size remains the same between now and 2020 (i.e. 2.58 residents per home), the total number of homes required in 2020 will be 126 million. The 36 million new homes constructed between 2001 and 2020 would represent 28.5% percent of the existing housing stock in 2020.

If these homes (or a significant percentage of them) were constructed in the cohousing model, or at least with lessons learned from cohousing communities and their design and construction choices, the nation's energy consumption could be noticeably reduced.

4.4.2 Smaller Homes

As noted in Section 3.3, the total residential sector energy consumption (excluding primary electrical and wood) is 9.84 quadrillion BTUs, with an average consumption of approximately 53,000 BTU per square foot of existing housing stock. Based on the assumptions in the previous section, and assuming that the average new home size remains 2,230 square feet (although historical trends show that it will likely rise), the total area of existing housing stock will grow from 186 billion square feet in 2001, to 236 billion square feet in 2020.[13] Assuming that construction techniques and personal consumption habits also remain largely unchanged, therefore not affecting the average energy consumption per square foot, the total residential energy consumption (excluding primary electrical and wood) in 2020 would be 12.51 quadrillion BTUs, an

[13] This area is the result of 126 million total homes, 90 million at the 2001 median of 1,736 square feet and 36 million at the current new home average of 2,230 square feet.

increase of 27% over 2001 consumption. The 2020 consumption estimate also represents an increase in the amount of energy consumed per resident from 35 million BTU to more than 38 million BTU, an increase of approximately 10%.

But what if new homes went back to the 1970 average of approximately 500 square feet per resident? What if the average home size constructed between 2001 and 2020 was not 2,230 square feet, but 1,300 square feet resulting in approximately 500 square feet per resident? Then the total area of household stock in 2020 would be approximately 203 billion square feet[14] which, assuming all other consumption habits remain unchanged, would result in total residential energy consumption of 10.76 quadrillion BTUs, an increase of 9% over current consumption, but 14% less than if housing sizes remain unchanged. If housing sizes would otherwise grow in line with historical trends, limiting the house size would result in even more dramatic savings. If housing sizes were decreased, the 2020 consumption estimate represents a decrease in the amount of energy consumed per resident from 35 million BTU to approximately 33 million BTU, a decrease of approximately 6%. The results of these calculations are summarized in Figure 4.5 on the following page.

[14] This area is the result of 126 million total homes, 90 million at the 2001 median of 1,736 square feet and 36 million at the assumed new home average of 1,300 square feet.

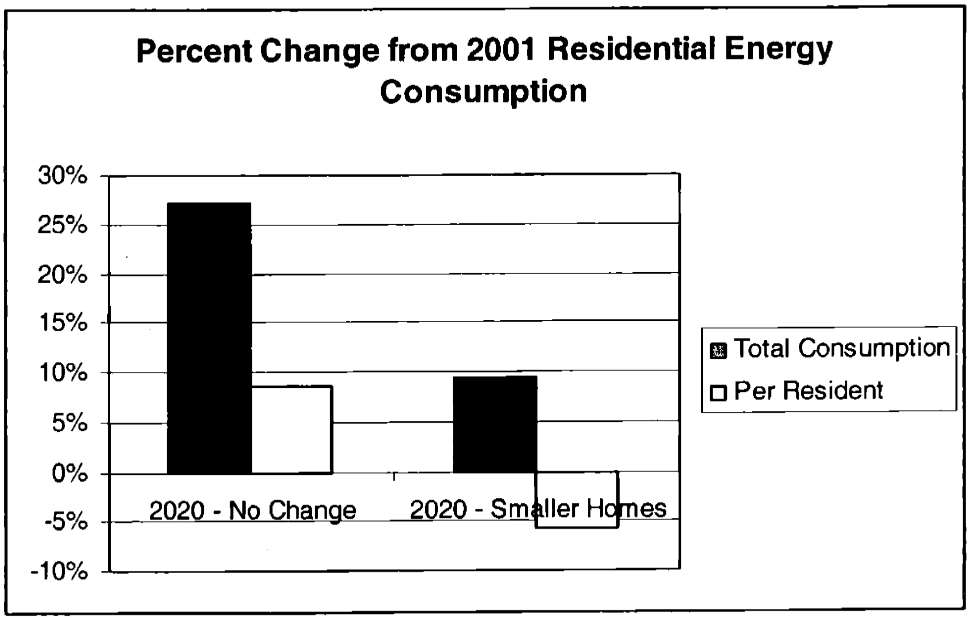


Figure 4.5: Estimated Energy Consumption Changes between 2001 and 2020

4.4.3 Energy Efficient Homes

It might not be very palatable for most people to sacrifice the space and luxury that they are accustomed to. So, while some may resist the idea of smaller homes, they may be more receptive to energy efficient homes. However, while reducing the size of the home results in both lower initial and life cycle cost, constructing a home to be energy efficient may actually result in a higher initial cost which would have to be offset by operating and maintenance costs over the life of the building. Most people would like to have lower energy bills but many are not willing to pay more initially.

The built infrastructure of both EVI and Cambridge Cohousing exhibit significant savings in energy consumption per square foot when compared with similar climatic regions, well in excess of 15% in most cases. For purposes of this analysis, a conservative estimate of a 15% reduction in energy consumption per square foot will be assumed to be reasonable and achievable. The economics of the reduction will depend on exactly which methods are used to achieve it, but given that both EVI and Cambridge Cohousing have made efforts to provide (and largely succeeded in providing) comparably priced homes within their market, this reduction is also considered to be economically viable.

Revisiting the assumptions in the previous section, it is assumed that there will be 36 million new homes constructed between 2001 and 2020, with 90 million of the existing stock remaining at that time. If the new homes remain the same size as they currently are (i.e. average of 2,230 square feet) the total area of housing stock in 2020 will be approximately 236 billion square feet.

If the new homes are constructed to be 15% more energy efficient per square foot, they will consume approximately 45,000 BTU per square foot versus the current nationwide consumption of 53,000 BTU per square foot. If these homes were added to the assumed 90 million homes remaining from the current housing stock, the total energy consumption in the residential sector (excluding primary electrical and wood) would be approximately 11.9 quadrillion BTUs, an increase of 21% over current consumption, but approximately 5% lower in 2020 than if no efforts are made to reduce consumption.

If smaller homes are constructed to be more energy efficient, the results would be dramatic. If 36 million homes were constructed at 1,300 square feet per home and consumed 45,000 BTUs per square foot; and these homes were then combined with the remaining 90 million homes which are currently a portion of the existing housing stock, the resulting energy consumption would be 10.4 quadrillion BTUs. This represents an increase of approximately 6% over current residential energy consumption while absorbing a 17% increase in the population between 2001 and 2020. This is a mere 0.3% annual increase in overall residential energy consumption while reducing the consumption per resident from approximately 35 million BTU to 32 million BTU, a reduction of 8.5%. These results are summarized in Figure 4.6.

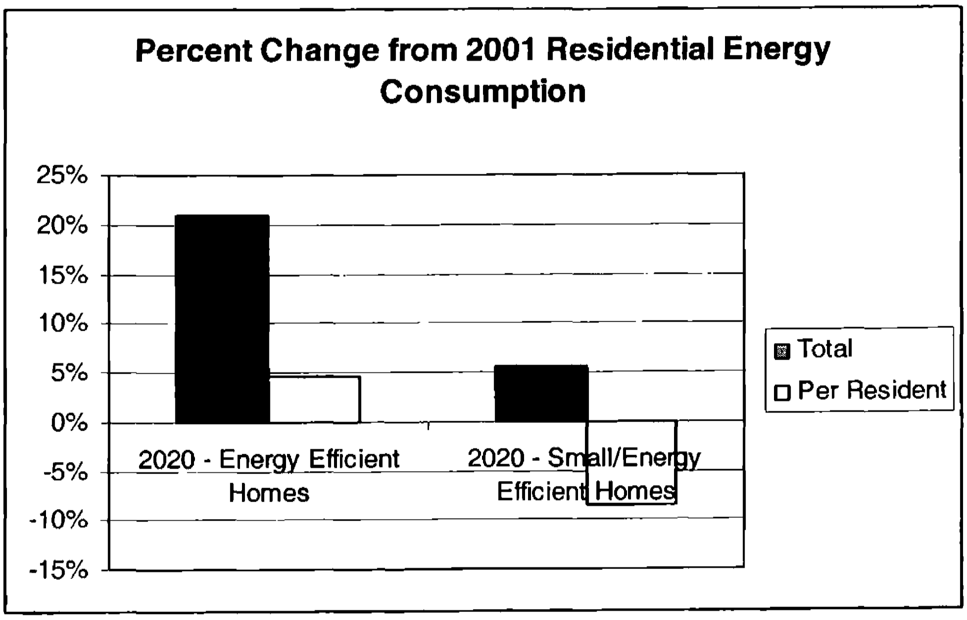


Figure 4.6: Estimated Energy Consumption Changes between 2001 and 2020

What is discouraging is that neither of these proposals (i.e. smaller homes or more energy efficient homes) nor the proposals when combined will actually reduce energy consumption in the absolute sense. They will simply provide a reduction over current projections and potentially reduce the consumption per person. However, as long as the population continues to rise, and without adopting draconian regulations which require a spartan lifestyle (some may already consider 500 square feet per person draconian and spartan) the nation's energy consumption will continue to rise.

4.4.4 Comparative Impact of Increased Fuel Efficiency Standards

How do the potential efficiencies in housing compare to savings in fuel consumption which may be realized elsewhere? For a comparison, we may consider fuel consumption of automobiles in the United States. According to the EPA, 40% of all U.S. oil is consumed in light vehicles (i.e. automobiles, pick-up trucks, SUVs, etc.). The average fuel efficiency for automobiles has remained largely unchanged since 1986, varying slightly around 24 miles per gallon (mpg). Light trucks have also remained largely unchanged since the same year, varying slightly around 18 mpg. The combined efficiency has varied between 22 and 20. For purposes of this thesis, the average efficiency of vehicles on the road is assumed to be 21 mpg (Hellman, 1-2).

The 2001 National Household Travel Survey reports that in 2001, 2.28 trillion household vehicle miles were traveled in the U.S. At 21 mpg, this represents the consumption of approximately 108 billion gallons of gasoline. Gasoline contains approximately 120,000 BTUs per gallon for a total energy usage of approximately 13 quadrillion BTUs in household vehicle traffic.

EPA further reports that since 1981 the overall performance of light vehicles has increased significantly with their horsepower increasing by 92% while their weight has increased by 24%. The EPA estimates that if this additional performance had been used to increase fuel efficiency rather than performance, today's vehicles would be 33% more efficient than they currently are resulting in an average efficiency of approximately 28 mpg which would have consumed 81 billions gallons of gasoline in 2001 or approximately 9.8 quadrillions BTUs, a savings of 3.2 quadrillion BTUs (Hellman, 4).

If the historical annual growth in vehicle miles traveled remains roughly the same between 2001 and 2020 as it has for the last 30 years, the estimated number of miles traveled in 2020 will be approximately 3.9 trillion miles. At current fuel efficiencies this would result in fuel consumption of approximately 185 billion gallons of gasoline or 22 quadrillion BTUs. If fuel efficiencies are increased to 28 mpg, the 2020 consumption would be 140 billions gallons of gasoline or 17 quadrillion BTUs.

By implementing wider use of currently available hybrid technology (i.e. capturing lost heat and friction from braking and turning in electrical motors which are used to supplement the internal combustion engine) even greater reductions are possible. Hybrid vehicles are capable of producing 20 or 30 more miles per gallon than traditional internal combustion engines. Accounting for further technological improvements, the added efficiency could be more dramatic. Conservatively adding 20 mpg to the currently possible 28 mpg (by shifting technological improvements from power to fuel efficiency) results in total fuel consumption rates of approximately 50 mpg. It would take 78 billion gallons of gasoline to travel 3.9 trillion miles at 50 mpg, or 9.4 quadrillion BTUs. This represents not only a per vehicle and per mile decrease, but a total decrease in the annual consumption of fuel for light vehicles of 30 billions gallons of gasoline or 3.6 quadrillion BTUs.

While the number of vehicles on the road and the number of miles traveled will indisputably rise in the next 20 years, the fuel required to travel those miles could be significantly reduced through more stringent fuel efficiency standards and utilization of existing technologies. Given the high turnover of vehicles as compared to residential dwellings, and with the dramatic potential savings the light vehicle sector is probably an even more attractive area to reduce overall fossil fuel consumption than the residential housing market. This is not to say that the potential savings associated with the housing market are not significant; simply that there are other potential areas which can be addressed to reduce energy consumption. If scarce resources are available to effect change, each potential change must be evaluated on its own merit and the potential reduction must be accurately quantified in order to provide a reasonable basis for comparison.

4.5 Other Opportunities for Reduced Fossil Fuel Consumption

In addition to cohousing and the corollary demand management techniques noted in the previous sections, there are other opportunities to reduce the nation's reliance on fossil fuels. While neither of the cohousing communities studied are currently implementing these opportunities, the size of the communities provide for economies of scale that may not exist in single-family homes, and therefore cohousing communities may be the ideal medium through which to bring these ideas to the residential market.

4.5.1 Cogeneration

Cogeneration refers to the technological process by which electrical and thermal power are generated simultaneously by capturing the otherwise wasted heat from an electrical generating process to create steam. These systems can operate at efficiencies of up to 90% (i.e. 90% of the chemical energy is transformed into electricity or heat for the home) and can reduce overall fuel consumption by 10-30%. The installed cost of a small system (like that which would be required for a typical cohousing community) would be approximately $2,200/kW of capacity. Detailed analysis of a community's peak demand (which would affect the overall size and cost of the installation) as well as the cost of the local utilities would need to be analyzed to determine whether or not cogeneration would be economically feasible. In addition to the primary benefit of reduced fuel usage, since both heat and electricity are being produced in the same process the consumer can purchase the primary fuel source (e.g. diesel fuel or natural gas) rather than relying on, and paying, the utility to convert the fuel to electricity and then distributing to the consumer. There are also various tax credits, grants, and buy back regulations which improve the economics of installing cogeneration facilities to consumers. Cogeneration also reduces the need for expensive and inefficient transmission lines. If properly configured a cogeneration facility can also be used to cool a space, in which case the process is called trigeneration.

Of course, cogeneration is not the final answer to ending U.S. reliance on fossil fuels, but consuming those fuels at 90% efficiency would reduce the cost and environmental impact of their combustion and cohousing communities offer the opportunity to use cogeneration while most living arrangements do not.

4.5.2 Wind Turbines

Similar to cogeneration facilities, wind turbines exhibit significant economies of scale. Larger turbines are typically more advantageous on a per unit basis than smaller ones. Other than the consumption of fossil fuels in the manufacturing and construction of a wind turbine and its associated appurtenances, wind turbines are fossil fuel free. While wind power is currently only economical when government subsidies are in place, the cost of wind power is coming down as it becomes more common.

Again, wind power cannot be the final answer in ending the nation's use of fossil fuels. Wind is inherently inconsistent and there are limited areas in the country where it makes sense to erect a turbine. However, cohousing communities are more likely to be able to economically implement wind power, and while communities powered by wind generated electricity would likely need a fossil fuel source backup or be tied to the grid, in some locations they can provide a significant offset to fossil fuel combustion.

4.6 Summary

The choices made by EcoVillage at Ithaca and Cambridge Cohousing have helped to reduce their energy consumption trends when compared with the relevant national and regional averages. While this is promising, it is important to use the appropriate energy mix to maximize economic potential and minimize environmental impact. Many of the principles used in the development of cohousing could provide for significant savings if they were implemented on a larger scale and the appropriate energy mix was used. Additionally, the scope of cohousing communities provides for economies of scale in using technologies that may not be feasible elsewhere. Chapter 5 analyzes the future of cohousing and anecdotally outlines potential obstacles to future development.

CHAPTER 5

FUTURE OF COHOUSING

Residents of EcoVillage at Ithaca and Cambridge Cohousing are leading the way with regard to reducing energy consumption in the residential housing market. Their commitment to sustainability and voluntary acceptance of smaller homes provides for significant reductions in energy consumption and provides a blueprint for others to follow in order to achieve the same reductions. While not every decision that they have made has achieved the desired results, they are experimenting with new ideas and techniques so that others may take the lessons learned and apply them over a broader population.

5.1 The Future of Cohousing

EcoVillage at Ithaca, Cambridge Cohousing, and other cohousing communities have led the way in reducing household energy consumption. The challenge is taking the lessons learned by cohousing pioneers and extrapolating them over a large enough population to affect national and global energy trends.

Cohousing, as of yet, does not appear to be scalable. That is, the amount of time, effort, and energy needed to take a community from conception to reality is more than most residents are willing to invest, given the relatively low impact choices available to those investigating housing options. While a significant, and growing, number of communities are successfully implementing the cohousing model, they still represent a mere fraction of the nationwide population and have done little (in the national, not personal, sense) to stem the accelerated rate of energy consumption in the U.S.

The future of cohousing will greatly depend not only on potential residents, but also on the ability of society as a whole to adapt to this emerging choice. Short-term, as noted in section 1.2, there are already 150 groups that are pursuing cohousing options. While history has proven that not all of these groups will be successful in implementing the model, if only half of them are successful, the number of developed communities in the U.S. would more than double in the next few years.

Alternatively if one looks at the historical growth rates of the last fourteen years and extrapolates the information out over the next 14 years, it appears that the potential for growth is even more dramatic. Table 1.1 (on the following page) outlines the growth rates for the two seven year periods from 1990-1996 and from 1997-2003 and provides estimates for the next two seven year periods 2004-2010 and 2011-2017:

Years	Number of Completions	Total Number of Completed Communities	Comp/Year	Percent Growth Rate Increase
90-96	22	22	3.14	
97-03	42	64	6.00	91
04-10 (est.)	80	144	11.45	91
11-17 (est.)	153	297	21.87	91

Table 5.1: Estimated Number of Cohousing Community Completions

Source: Cohousing Journal, Spring 2002

Note: 2003 Data is derived from April 2003 press release noted above; some communities may have been completed in late 2002

If the 91% increase in the growth rate per year is maintained for the next two seven year periods, by the end of 2017, nearly 300 cohousing communities will be complete and operational, with approximately 20 more being added each year. (If one assumes that each community is roughly 25 households with an average of two people per household, the total number of people living in cohousing communities could reach 15,000 people by the end of 2017.) While I hesitate to extrapolate the information beyond 2017, even if the total number of communities double every 7 years it would take generations before any significant impact to national trends occurred. If cohousing is to impact national energy trends, not only must the number of communities continue to rise, but the rate of increase would also have to rise. Cohousing must be vigorously marketed and obstacles to community development must be removed, but realistically cohousing will provide the greatest impact by simply setting a standard for community and sustainability by which others can compare themselves.

The cohousing market, currently and based on current projections, is and will remain a niche market. There is room for specialized expertise among developers, designers, and possibly contractors (although their duties are more similar to their general processes than the other two) but due to the limited number and geographic dispersion of the communities currently being planned, it is unlikely that any firm in the design and construction value chain can rely solely on cohousing clients for their revenue. Developing the expertise necessary to meet the needs of cohousing developments would be advisable, but each firm involved in cohousing should remain diversified enough to ensure that they have other sources of income.

5.2 Obstacles to Cohousing

Despite the potential benefits and positive impact of cohousing, there are still obstacles in the way of developing communities. Many neighbors of potential communities are unsure of what to expect from the new community. They fear overdevelopment, increased traffic, and that their property values may drop. Additionally, while cohousing communities do not resemble, and actually make an effort to distance themselves from the communes of the 1960s, there appears to be lingering resistance among potential residents to accept the idea of intentional communities. Also, many zoning regulations do not lend themselves to cohousing, requiring the future residents to ask for waivers which may or may not be granted. Financing a relatively new model with its associated risk can also be a challenge.

One recent example of the challenges presented to potential cohousing groups can be found in Stow, MA. On November 7, 2002, the Boston Globe reported that a cohousing group, Mosaic Commons, made a $1.1 million offer on a 50 acre plot of land on Red Acre Road near Stow. Concerns regarding the density of the development and the detraction to the attractiveness of the plot were published in the story. However, Mosaic Commons contended that many of their future neighbors' concerns were unfounded: they would only develop a small portion of the plot and donate more than 40 acres of protected wetlands back to the town; their presences would not dramatically increase traffic because the cohousing model encourages more interaction within the community therefore reducing the amount needed outside of the community; and, since the community was developing their future home, they had a vested interest in maintaining the ecosystem their neighbors were concerned they would disrupt.

By December 5, 2002, a competing proposal was put before the city council. Due to zoning regulations in the area, the city had the first right of refusal and a group of concerned citizens were asking the city to either exercise the first right of refusal and help them develop a home for abused and abandoned horses, or grant the right of refusal to the group proposing the horse shelter and allow them to develop it themselves. Either way, the cohousing group would not be sold the land and they would not be able to develop their community.

On January 16, 2003, the Globe reported that the city had blocked the sale to Mosaic Commons and that they would attempt to move forward with the horse shelter plan. However, subsequently voters chose not to use public funds for the shelter meaning that the group would have to procure funds from alternate sources. The city did turn over the first right of refusal to the group proposing the shelter, and they matched the offer of Mosaic Commons, effectively ending the possibility of cohousing on the site.

However, in October 2003, the Globe followed-up their earlier reports noting that the seller of the land was alleging breach of contract against the shelter development group due to lack of payment. The report states, "Craig McDonnell, the Massachusetts Director for the Trust for Public Land, said a slow economy thwarted fund-raising efforts and a sizable state grant fell through." So nearly a year after Mosaic Commons made an offer for the land, the group opposing their development succeeded in nothing but that—opposing their development.

It's easy to see why some potential residents would become disenfranchised with the pursuit of cohousing. In more traditional developments, these situations do still occur; however, their burden is borne by the developer for whom its business, not the future residents for whom it may be personal.

However, even considering these challenges, cohousing has proven to be a durable housing arrangement in Denmark and throughout northern Europe. The U.S. movement, while fairly young, is still expanding and the process is becoming easier with each successful implementation of the model. Financiers, constructors, and designers will learn to take part in cohousing development as long as they expect an equitable return on their investment. Regulations and governmental incentives will likely follow once the advantages of cohousing are fully understood. The question is will the American consumer begin to demand a housing option which offers community and sustainability rather than isolation and over-consumption.

CHAPTER 6

CONCLUSIONS

6.1 Consumer Implications

How can we make an impact on the nation's energy trends? If history is any indication, the populace of the United States will not accept regulations limiting their ability to purchase whatever is within their purchasing power. The inability to pass rational legislation increasing fuel efficiency standards on automobiles is a prime example. The technology exists to double or even triple the fuel efficiency of automobiles with little or no impact on their ability to perform adequately under normal driving conditions. Similarly the technology and precedent exists for homes to consume less energy with little or no impact on the homes ability to adequately house the residents.

However, the rising size of homes and rising numbers of vehicles with low fuel efficiencies on the road are clear indicators that the average American consumer is not overly concerned about the cost or future availability of fuel. As Peter Senge, author of

"The Fifth Discipline", said at the 2004 Northeast Sustainable Energy Association Conference in Boston, Massachusetts, the 800 pound gorilla in any discussion related to sustainability is American consumerism and how it drives the geo-political agenda. In short, no one wants to hear or talk about the fact that we must simply reduce our standard of living, or as Gregg Easterbrook advises in "The Progress Paradox", "...we must awaken from the dream and realize that an overall condition of personal freedom and material prosperity does not make us any happier." He cites research indicating that once an individual earns approximately $10,000 per year, there is no longer any correlation between income or wealth, and happiness. Since the 1950s, the self-reported percentage of respondents that say they are happy has remained at approximately 60%. During this same period or time, housing sizes have tripled on a per resident basis. Apparently there is no correlation between house size and satisfaction. (Easterbrook, 170-187). However, the American consumer continues to consume more fossil fuels, of which the world has less every day, presumably in an attempt to increase satisfaction through larger, more opulent homes and vehicles.

Ideally, an enlightened populace would realize the wastefulness of our current consumption habits and voluntarily reduce our level of consumption. However, without expanded awareness of the problem, education regarding the potential ramifications and acceptance of the situation by the populace, voluntary efforts will not suffice. Reducing consumption cannot, and should not, be forced from the government on the people, however, the government can take reasonable steps to ensure that we are not rewarding inefficiency and removing incentives for reasonable attempts to reduce consumption of fossil fuels. Those who want to live more sustainably should be given the full support of the federal and local governments, and should be evaluated based on the merit of their proposal, not impeded simply because they are trying something out of the ordinary.

Reasonable attempts to internalize what are currently external costs should also be researched. Currently there is no financial incentive to reduce fossil fuel emissions because the cost of an incremental amount of carbon dioxide in the atmosphere is very difficult to estimate and no consensus regarding the value has been reached. In the book "Natural Capitalism" the authors cite research indicating that the atmospheric regulations of gases is worth $1.3 trillion (Hawkens, 154). If an equitable value of carbon dioxide emissions can be agreed to, these emissions could be taxed or traded (similar to sulfur dioxide trading in the U.S.) and the real cost of fossil fuel consumption could be borne by the consumer which would provide an incentive for reducing their consumption.

6.2 Further Development

This thesis provides indications of factors which lead to reduced energy consumption in cohousing. Providing definitive determinations of which of these factors play the greatest role in that reduction and a detailed economic analysis of each factor are important areas of research. Additionally, research into what could be done to streamline the cohousing community development process would also be valuable.

Research into the construction value chain in general, and housing development specifically, could be conducted in order to determine what role the delivery method plays in the life cycle cost of the building. Currently those primarily responsible for initial cost (i.e. developers, contractors, and designers) are not the entities that are responsible for the operational cost of the building (i.e. occupants, property managers). It would be interesting to see if a build-operate-transfer (BOT) delivery method would improve the life cycle cost and reduce the energy consumption of the building by shifting the responsibility for maintenance and operations to the developer.

Policy questions regarding the desired level of support for cohousing and the form in which that support would come would also be valuable. Most importantly, research needs to continue with regard to how to promote demand management techniques and energy efficient technologies in order to reduce the nation's reliance on fossil fuels with a minimum economic impact.

6.3 Summary

While cohousing cannot be the sole answer to reduced energy consumption in the residential sector, the choices made by cohousing residents could provide a means for achieving significant reduction in nationwide consumption. Both EcoVillage at Ithaca and Cambridge Cohousing exhibited significant energy reduction by all measures over the relevant population averages, and there is no reason to believe that existing and still developing cohousing communities could not achieve similar reductions. More importantly, cohousing communities offer an example to those that choose other housing options and provide a framework by which each of us, independent of our specific living arrangement, may reduce our personal energy consumption.

The Energy Information Administration of the United States Department of Energy reports that in 2001 the United States consumed 96.2 quadrillion BTU (quads), of which 21.2 quads were consumed by the residential sector (23% of the total) (Latta, Table CE1-1c). If residential consumption could be decreased by a significant percentage, the overall effect on the nation's consumption habits would be quite noticeable. While addressing residential consumption will not answer all of the questions regarding energy consumption and reduction in the U.S. reliance on foreign sources of oil, it is a good first step. Due to the relatively quick turnover of residential sector assets as compared with the rest of the built infrastructure, a residential demand management program could provide relatively short-term results.

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