# URBANIZE AND INSULATE

## The Development of a Fossil Fuel Exit Strategy

Dylan Lamar

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Cover printed by hand on a Vandercook press.

# Acknowledgments

I owe so much to so many. First and foremost, many thanks to Hans Edwin Winzeler for his invaluable commentary, which improved the quality of this document tremendously. Thanks to professor and research architect William Rose of the University of Illinois Building Research Council for his insightful feedback and critical eye. Thanks to Stephen Aiguier for his inspiring leadership and the financial support of Green Hammer in publication. Thanks to the many professors and fellow students who have guided me throughout my studies, most notably at the University of Oregon. Thanks to Katrin Klingenberg for her support in my Passive House education.

I would also like to acknowledge the planners of the City of Portland of decades ago who sewed the seeds of the walkable, urban district in which this book was produced.  All of the materials and services needed to produce this book—from printing plate engravers, to letterpress cooperatives, to paper supply companies, to commercial printers—were all found within a bikable mile of my home (several coffeshops, restaurants and bars were also helpful).

And finally, a deep bow to the Zen teachers who help me to stop thinking too much and face whatever arises with relish.

This book is dedicated to the power of such collective effort.

# Contents

# Preface

We are surfing the wave of a life time—a surge of energy that comes along once in a few trillion years perhaps. This is the relative impact of fossil-fuels on humanity and Earth's ecosystems. But as empowering as the wave has been—fueling the industrial revolution and everything we now define as the modern world—the cloud of exhaust in its wake is rapidly warming the Earth to deadly proportions. Scientists tell us we yet have the ability to solve this problem. In fact, this book will demonstrate that we can solve this and a few other problems as well, all while actually *improving* our livelihood. We can live in a vibrant neighborhood instead of a monotonous subdivision, and enjoy easy access to all the amenities provided by walkable, urban places, free from the worries of rising gas prices. We can live and work in "Passive House" buildings of exceeding comfort with nothing more than a hair dryer for a heater. And we can be happy—even happier than we are now—without compulsively buying so much. We can do all these things even while we stop climate change. And we can ride that killer wave with grace, peacefully into shore.

This peace requires weaning modern industrial society from fossil fuels, and it is truly an all-encompassing issue. It requires reassessment of nearly every conceivable aspect of our human activity. Recognizing that change must occur at a very fundamental level, this book focuses on the built environment—specifically where, what, and how we, as Americans, build. The book takes a multidisciplinary perspective drawn from five years of master's studies and work experience in the field of energy and buildings. It draws from experience with some of the most advanced practices and understandings from a variety of disciplines. This document is an attempt to succinctly integrate this forward-thinking knowledge so that it may be of benefit to planning and building professionals with ambitions to realize a sound future but with limited time for such research. By painting a more holistic picture of this proactive paradigm shift away from fossil-fuels, it is demonstrated that we can realize a better future for America, for humanity, and for all the earth's species.

# Introduction

*"We cannot solve our problems with the same thinking we used when we created them."*

—Albert Einstein

We stand now at a precarious epoch in the story of humankind. After several thousand years of relatively slow and steady growth, fueled at most by wood-burning fire, humankind has in the past two-hundred years harnessed the incredibly concentrated power of fossil fuels which has triggered no less than an eruption of population and activity. Rapid change is the hallmark of this age—ancient traditions fall away as local cultures and crafts respond to global industrial forces.

And yet, this energetic heyday will be short-lived. As growing demand consumes a finite supply, fossil-fuel resources will be depleted as quickly as they were exploited and what will remain of them is a tremendous amount of atmospheric pollution that has already begun and will continue to warm the planet, possibly to a catastrophic degree depending on our present-day actions.

Indeed, we have a choice in this moment. We can shrug our shoulders and resign ourselves to fate, we can grasp desperately to a self-righteous view and spend our time blaming others, or we can recognize the timeless qualities of true humanity—wisdom and compassion—and work to cultivate them. This is not mere rhetoric. It is the difference between proceeding with fear and anxiety or unrelenting level-headed optimism in the face of certain hardship. Each of us has many opportunities in our daily lives to succumb to the status quo disinterest in our looming troubles and to allow the dominant paradigm to persist. Or we can face the facts and recognize the need for a fundamental paradigm shift in how we as humankind live. What to do at that point is the topic of this book—at least where the built environment is concerned. This book seeks to help planning and building professionals and policy-makers understand the clear priorities of a fossil-fuel exit strategy so that we can make decisive and effective corrective actions.

It has been said, "infrastructure is destiny".[1] Forward-thinking action within the planning and building industry is necessary because the present infrastructure (and structure) of our built environment requires abundant and affordable energy to function at even a primitive level. Even with major lifestyle changes—wearing extra sweaters to keep warm and carpooling to work—significant fossil-fuel dependence would remain in our existing society. Suburban housing is of such low density that mass transit cannot provide affordable service, and buildings are so poorly insulated that without substantial heating occupants risk hypothermia. We are not well poised to sustain ourselves with any sense of stability as fossil-fuel supplies become less and less affordable—much less are we in a position to voluntarily eliminate their use in order to redress our carbon footprint.

This document starts by analyzing the context and values which got us to this point in time, and proceeds by critically analyzing two basic elements of the human-built environment:

**Development Pattern**—where and what we build (or rebuild), and
**Building Fabric**—how we build

It seeks to paint a clear picture of what is currently wrong as well as concrete examples of how the situation can be reversed. While these two topics are at vastly different scales—one being measured

1 "A Conversation with Robin Chase" Urban Omnibus and The Infrastructurist. June 10th, 2009. Retrieved October 1, 2009. http://urbanomnibus.net/2009/06/a-conversation-with-robin-chase/

in terms of miles and another in terms of inches—and divided into distinct disciplines, professionals acting at any stage will benefit by understanding the fundamental rethinking that is possible on all levels. Architects, especially, should understand the priorities at both scales since their work so often spans the gamut.

In addition, this text goes beyond the technical by also questioning the dominant human values which seem to have created our current dilemma, and recognizing that the heart of the problem as well as its solutions lie there. For example, energy efficiency alone does not necessarily decrease energy use, for it may simply allow money and energy to be spent elsewhere. A conserving attitude is necessary in addition to efficiency. But will this conserving attitude be self-motivated or imposed upon us?

Change is inevitable. In the case of a fossil-fuel exit strategy, the question is whether change will come proactively or reactively. In a proactive scenario, building and planning professionals will take an active role in reversing long-standing policies which require abundant energy consumption (i.e. low-density, segregated-land-use zoning and insignificant energy codes). As this book will demonstrate, these infrastructural changes can not only reduce carbon emissions tremendously but also greatly improve our quality of life. Through such inspiring, proactive change we may yet learn to thrive without fossil fuels. This reversal of the status quo will not proceed without difficulty, but unless we put forth this effort, we will not sustain a stable future for humanity.

In a reactive scenario, we will continue to burn coal after oil is no longer affordable and by the time climate change is so disruptive as to be undeniable, centuries of further change will have been triggered and unstoppable. Having seen the impact that Hurricane Katrina had on the US economy, we can be sure that year by year, decade by decade, as droughts and flooding disrupt our agricultural base and devastate coastal cities, displacing millions, political and military struggles will mount and the global human condition will become dominated by suffering.

For the sake of future generations, the potential depths of this hell should be acknowledged.

The consequences of which of these paths we choose today—here and now—are tremendous (Figure1). The sooner we act, the greater our opportunity for peace and prosperity. Will we correct our unsustainable policies now, or will we pass these problems, by then unsolvable, on to future generations?


Figure 1: Boston, Massachusetts visualized with the three-meter rise in sea level which is predicted by climatologists in a business-as-usual scenario (simulated flood water is highlighted) (source: Architecture 2030).

# Context

Being faced with such dire problems as climate change and fossil-fuel depletion, it is helpful to take a step back and understand more fully the trajectory which has brought us to this point. Such perspective can allow us to better identify the root of our problems, and better inform the best course of action from this point in time.

From the advent of humankind until about two hundred years ago—a span of millions of years—human societies were fueled primarily by the sun. From agriculture to firewood, solar energy fueled the resources on which humankind depended. And through the ages human societies have learned to manage these resources through trial and error. At a basic level, those which maintained sustainable relationships with their environment continued, those which did not suffered and often failed. Clive Ponting's *A Green History of the World* reveals many examples of this process, from ancient Mesopotamia to medieval Europe.[2] Reading these histories is humbling, and one realizes how foolish it is to take our modern industrialized society for granted.

As it so happened, bit by bit some of the organic matter of the solar-driven ecosystem on earth found its way into subterranean reservoirs where it accumulated in great quantities over millions of years. The discovery of these "fossil fuels" marked a monumental shift in the trajectory of humankind. With this unprecedented supply of energy, made readily available on-demand through combustion, the industrial revolution quickly transformed the scale and pace of human industry on the earth. The impact of fossil-fuel discovery on human population growth could not be more profound (Figure 2).

2 Penguin Books, 1993; Updated edition, 2007.

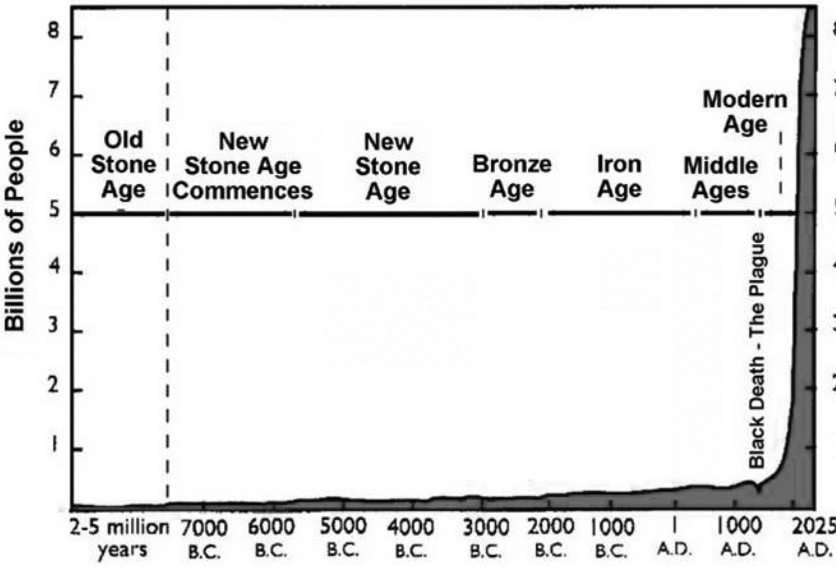


Figure 2: Human population growth through history (source: "World Population: Toward the Next Century" Population Reference Bureau, 1994).

With this unprecedented change, many damaging side effects have also occurred at unprecedented levels, namely the depletion of natural resources and the proliferation of environmental pollutants. The trial-and-error development of early human societies is now occurring on a global scale to the point that two major problems now confront humankind globally—climate change and peak oil.

Atmospheric pollution from the combustion of fossil fuels is causing more solar energy to be absorbed by the planet, causing the earth to warm and disrupting natural processes globally. This climate change currently poses a serious threat to the stability of human societies as well as millions of species of life. As NASA scientist James Hansen testified before Congress in June of 2008,

> if emissions follow a business-as-usual scenario, sea level rise of at least two meters [six feet] is likely this century. Hundreds of millions of people would become refugees. No stable shoreline would be reestablished in any time frame that humanity can conceive.

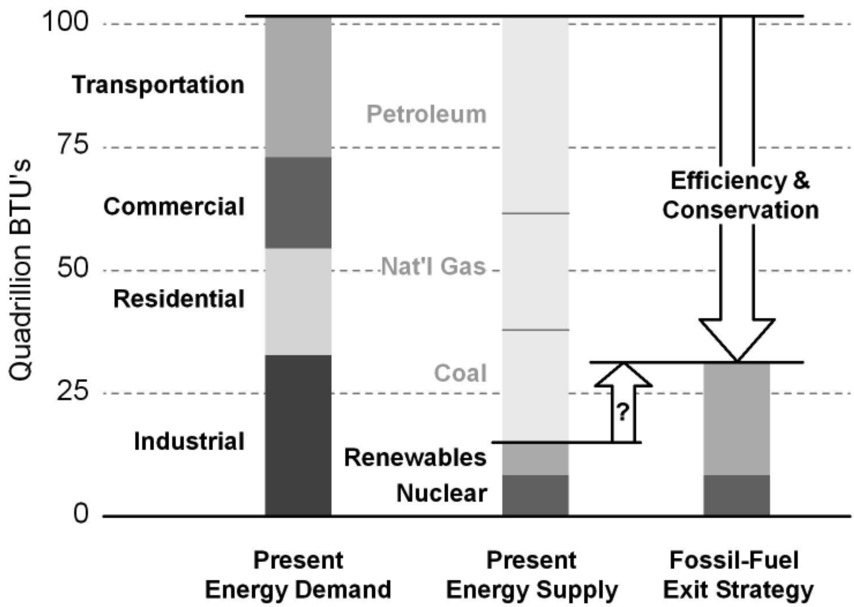


Figure 6: US Energy Demand and Supply: The fossil-fuel exit strategy is characterized by efficiency and conservation across all sectors followed by a sound investment in renewable energy (Data: Energy Information Administration, Annual Energy Outlook 2009)

The next industrial revolution requires a paradigm shift in human activity and it starts with the very foundations of industrial society—from our cultural obsession with "economic progress" to the physical infrastructure of the built environment. Truly, the greatest challenge is not technical innovation, but rapid cultural and institutional change. Policy-makers and professionals of the building industry have a unique opportunity to facilitate this proactive change—to plan and design with a fossil-fuel exit strategy in mind so that our children (and children globally) may live without suffering the consequences of our transgressions. Indeed, the future stability of the industrialized world depends on it.

Yet such a paradigm shift must be internalized on a personal level, and so let us take a closer look at our values and assumptions.

# Values

*"You must be the change you wish to see in the world."*

-Mahatma Gandhi

In his timely book *Collapse: How Societies Choose to Fail or Succeed*, Pulitzer prize-winning author and evolutionary biologist Jared Diamond concludes that two attributes seem to characterize successful societies: long-term planning and an ability to change core values.[10] The fossil-fuel exit strategy proposed here is central to the issue of long-term planning, but as Diamond suggests, this cannot be isolated from an inquiry into values. This chapter takes a brief look at the predominant values of Americans, and examines their appropriateness given the challenges which face us. It will argue that *adaptation* of our values to these problems is critical to our success as a society.

Historically, America is a nation of self-starters. Compared to other industrialized countries our population is highly individualistic. While the American population as a whole has more expendable wealth than most other nations, we have some of the most poorly funded public schools. Similarly, libertarian resistance to government regulation is strong. On the one hand, government regulation of

10 Viking Press, 2004.

> Shopping centers have become the centers of our public life, and consuming has become both our primary means of self-definition and our leading pastime.[16]

All of this consumption has a tremendous impact on the environment, as poignantly illustrated by Annie Leonard's online video "The Story of Stuff" (www.storyofstuff.org). And yet, chasing after these transient, materialistic desires does not increase happiness, as psychological studies clearly confirm:

> After World War II people had no computers or televisions, indoor plumbing was not taken for granted, and many people had ice boxes rather than refrigerators. Yet people report being about as happy as they are now. Thus we must question then whether we need a trip to Antarctica, a larger home with more bathrooms, and a high-status automobile to be truly happy. Certainly if these items require us to make sacrifices in self-growth, leisure time, and intimate relationships, they may interfere with happiness rather than enhance it.[17]

Economic development beyond poverty is necessary to enjoy a stable quality of life. But beyond this, a higher material standard of living does not necessarily correspond to a greater quality of life. When material wealth is pursued amidst a culture of competition and consumerism, happiness is continually out of reach as material desires extend ever further even as higher levels of wealth are attained. Quite simply, as long as you think you need something more to be happy, then you're not going to be happy with what you've got.

Figure 7 suggests an alternative pursuit of happiness, one where the craving for ever more material possession is recognized as the disease that it is. While many approaches are possible, increased self-awareness is of basic necessity in transcending consumerist habits. Through greater self-awareness, fulfillment is seen to come from a change of perspective rather than a change of clothes or car. Like a

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16 Alan Thein Durning. How Much is Enough? The Consumer Society and the Future of the Earth. W. W. Norton & Co. 1992. p 7-8.

17 Ed Diener and Shigehiro Oishi. "Money and Happiness: Income and Subjective Well-Being across Nations" *Culture and Subjective Well-Being*. The MIT Press, 2000.

dog chasing his tail, it's simply necessary to realize the ridiculousness of what we're doing. When we become aware of how our habitual craving for "something better" actually prevents our happiness, we are empowered to move forward and focus instead on appreciation. As we turn our attention to behold the subtle miracle that is our life, our relationships, and our environment, we can realize how naturally wealthy we truly are. As awareness expands, as we become less self-absorbed, we can see how intertwined our own happiness is with the happiness of those around us. We may see our intrinsic interdependence in this way and transition from a self-centered to a life-centered mind set.

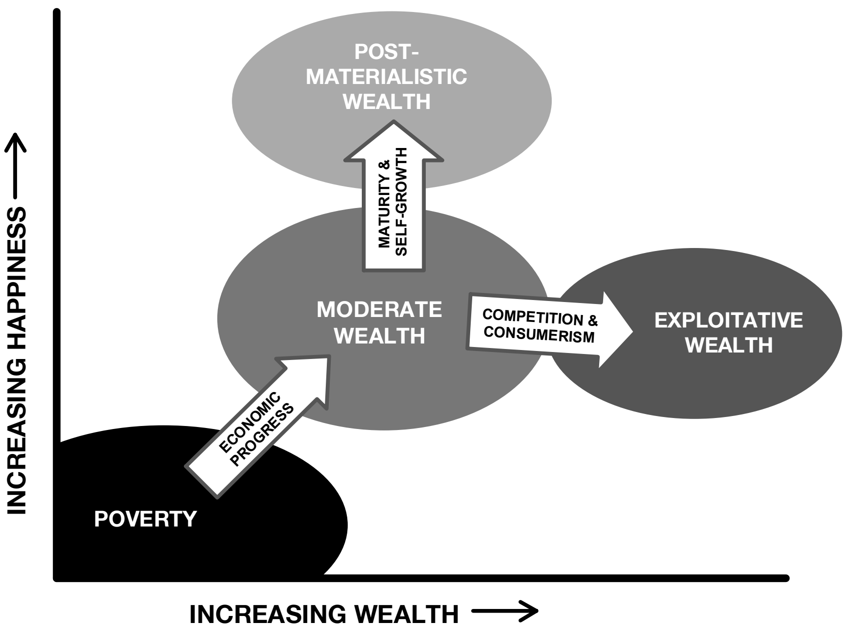


Figure 7: An alternative view of the pursuit of happiness.

The qualities that lend meaning and value to our life experience are inherently free and available, we simply need to cultivate our awareness and appreciation of them. In this way, simplicity in activity and possession yields clarity and appreciation not sacrifice. This is true wealth—post-materialistic wealth—and it requires no fossil fuel.

# Development Pattern—Past & Present

## The Advent of Drivable Suburbanism

The traditional, pre-industrial city was a pedestrian-scale urban environment. Development was centralized and compact. Living, working, shopping, and leisure environments were interwoven in a tightly knit matrix of interconnecting streets by necessity because transportation was typically on foot. This basic walkable urban pattern served cities from ancient Mesopotamia up to 19th century America. In a pre-industrial American city of modest size a typical building on a prominent street might be three or four stories with a business on the ground floor and residences or offices above. On the side streets were a mix of apartments, attached townhouses, and single-family detached homes. A neighborhood park was down the street. In the modern American city, large or small, conventional zoning codes have completely departed from this traditional, pedestrian-scale pattern.

As with so many things, industrialization resulting from fossil-fuel use brought significant change. The scale of industry facilitated by coal-powered steam locomotives introduced significant air and noise pollution and congestion into urban centers. Naturally people sought to live in a more healthy setting, and by 1900 the electric streetcar allowed a growing number of middle and upper-class people to find refuge in sub-urban residential enclaves which supported their agrarian ideal. By the 1920's streetcar transit was ubiquitous throughout American cities and, as urban geographer Peter Muller explains,

> many geographers and planners would agree, that intrametropolitan transportation achieved its greatest level of efficiency—that the burgeoning city truly 'worked'. How much closer the US metropolis might have approached optimal workability for all its millions of residents, however, shall never be known because the second urban transpor-

tation revolution was already beginning to assert itself through the increasingly popular automobile.[18]


Figure 8: Electric streetcar transit was ubiquitous throughout American cities between the 1890's and 1930's, allowing the separation of housing from congested urban areas

Simultaneously in the 1920's city planners throughout America adopted land-use zoning ordinances. These controversial regulations sought to ease urban tensions by separating "incompatible uses". Industry, business, and housing developments were segregated into separate zones in order for the city to more efficiently function, it was said, like the harmonious workings of the separate organs in a human body.[19] While such a strategy logically distanced housing from the pollution and congestion of industry, the strategy was also exploited for less noble purposes.

Motivated less by technical efficiency than by socio-economic discrimination, zoning was used to segregate single-family detached housing from attached housing. Those of higher social standing—which would have included the authors of zoning laws—naturally sought to secure their status by distancing their homes from those of lesser means. Muller explains that zoning "gave municipalities control of lot and building standards, which, in turn, assured dwelling prices that would only attract newcomers whose incomes at least

18 "Transportation and Urban Form: Stages in the Spatial Evolution of the American Metropolis" Ch 3 from Hanson, S. and G. Giuliano. *The Geography of Urban Transportation*. New York: The Guilford Press, 2004. p69-70.

19 Dana Caspall and Joseph Schwieterman. *The Politics of Place: A History of Zoning in Chicago*. Lake Claremont Press, 2006.


Figure 9: Before the adoption of zoning ordinances single-family and multifamily housing was typically interwoven. A mix of housing types on the same block was not uncommon as in this block in Gettysburg, Pennsylvania with an apartment building, duplex, and single-family homes in succession. In fact, one of the row houses is also home to a barber shop (the barber pole is just visible above the car). This block would be highly illegal by conventional zoning codes because of this mixed-density housing and mixed-use (both residential and commercial).

Through the 1930's and 40's the automobile increasingly supplanted the streetcar as the suburban mode of transportation. Importantly, this was at least partially due not to public demand for the automobile, but to industry collusion. At a time when only 1 in 10 American families owned an automobile, General Motors, Firestone, Standard Oil along with several other corporation, working anonymously through a subsidiary organization, systematically bought and dismantled more than 100 electric streetcar systems in 45 cities, from New York City to Los Angeles.[21] In their place the company promoted "motorized!" bus service which was clearly less attractive than the smooth, quiet, and clean operation of electric streetcars. As GM likely

21 Bradford C. Snell. *American Ground Transport: A Proposal for Restructuring the Automobile, Truck, Bus and Rail Industries*. US Gov't Printing Office, 1974.

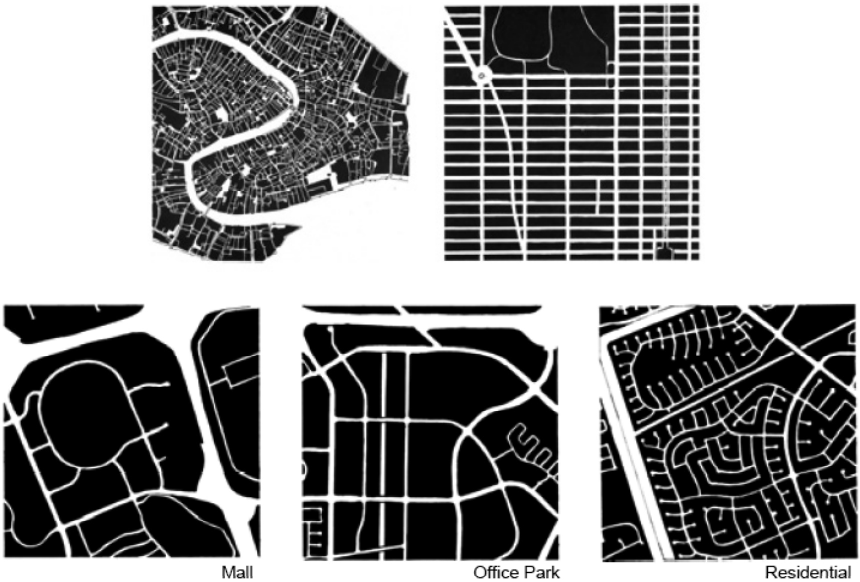


Figure 13: These maps, each covering one square mile in different built environments, highlight the stark difference between traditional interconnected street networks supporting walkability (top) and the auto-dependent street networks of suburban development (bottom). Clockwise from top left: Venice, Italy; New York City; Pleasanton, California (lower three) (Source: Jacobs, Allan B. *Great Streets*. The MIT Press, 1995).

At the scale of the city, the segregation of land-uses and the preeminence of suburban sprawl development has weakened the bonds of social responsibility between the urban core, and the disparate suburbs. It has caused a disparity of school funding, reinforcing socio-economic inequalities in future generations. As the scale and experience of the built environment became dominated by the automobile, the private, socially-isolated realm has come to dominate the American lifestyle: from private homes, separated from others by law, people are transported within the private space of their automobile (if they have one) to private working and shopping environments. Private indoor shopping malls serve the social-gathering function once provided by public plazas and “Main Street” streetscapes. Weekend recreation at public sports fields may be the only regular activity in a public space. Indeed the cultural vacancy of suburbia is increasingly apparent among younger generations. The sense of vibrancy and community that comes from an area with a concentrated mix of uses and users is completely gone. As architect and urban designer Dan Solomon points out,

> most people who live in the new [suburban] places come to the old [urban] places all the time for things they don't have: streets where you can walk around, bars and cafes, music, theatre, and such. People who live in the old places tend to go to the new places only when they have to—for work or to go to the airport or places that discount tires.[26]

The almost exclusive development of low-density, single-use suburban environments in the past sixty years has had a socially-isolating and socio-economically segregating effect on the American lifestyle.

Ironically, while the desire for safety was a primary motive of suburban flight, suburban life is increasingly insecure due to its dependence on cheap and abundant fossil-fuels. With distances between home, work, school, and friends that are unprecedented by any other society in human history, conventional suburbia cannot efficiently function without the personal automobile: "from World War II until very recently, nearly all new development has been planned and built on the assumption that people will use cars every time they travel."[27] Quite simply, zoning laws compel automobile use. And with increasingly volatile fuel prices amidst the crest of peak oil, automobile dependence is now a great source of insecurity for a majority of Americans. This dependence certainly influences our campaigns of warfare in the Middle East and, with hostile religious factions on both sides, the threat of further violence is high as the energy resource which suburban livelihood depends on becomes ever more scarce.

As a direct consequence of this tremendous fossil-fuel demand, the carbon emissions resulting from suburban development are also tremendous. A recent engineering study in Toronto found that a single-family house on the suburban fringe resulted in 2.6 times as

26 Daniel Solomon. *Global City Blues*. Island Press, 2003.

27 Reid Ewing, Keith Bartholomew Steve Winkelman, Jerry Walters, and Don Chen. *Growing Cooler: The Evidence on Urban Development and Climate Change*. Urban Land Institute, 2008.

# The Development Pattern of a Fossil-Fuel Exit Strategy

## From Drivable Suburbanism to Walkable Urbanism

Whereas the need to reform the congested industrialized city drove urban planning in the 20th century, the need to reform the sprawled metropolitan region drives urban planning in the 21st century. Due to mounting social, environmental, and economic costs, we clearly need city planning which facilitates more sustainable development.

The personal automobile plays prominently in the costs of sprawl: it reinforces social isolation, it accounts for the majority of personal greenhouse gas emissions, and it weighs heavily on both infrastructure costs and household finances. No simple solution, such as electric cars, can address these problems. For example, while automobile efficiency can and should increase dramatically, studies show that the growth in driving due to sprawling suburban expansion has outpaced population growth by a factor of three since 1980, and this land-expansion effect overwhelms the increases in vehicle efficiency currently mandated by 2020 (35 mpg for passenger cars).[29] Even with more radical efficiency improvements, the intrinsic inefficiency of transportation within a low-density, segregated-use metropolitan region precludes alternative forms of transportation such as walking and biking—low-cost, carbon-free, healthful alternatives—as well as quick and accessible public transit.

Nothing short of a complete paradigm shift of the conventional development pattern is necessary to end our dependence on fossil-fuels in a time frame that prevents catastrophic global warming. Further, this is a low-cost solution because "it involves shifting investments that have to be made anyway... two-thirds of the development on the ground in 2050 will be built between 2007 and then."[30] In this paradigm shift three fundamental factors must appropriately align: density, land-use planning, and transportation planning.

29 Ewing et. al. p2-3.

30 Ewing et. al. p8.

Figure 16: Apartments such as these, built before parking requirements were mandated by zoning codes, integrated well with neighboring single-family housing. They allow the housing density in this Portland, Oregon neighborhood to reach a point that workplaces, shops, churches, and schools can all be located within walking distances, making car ownership an option rather than a necessity.

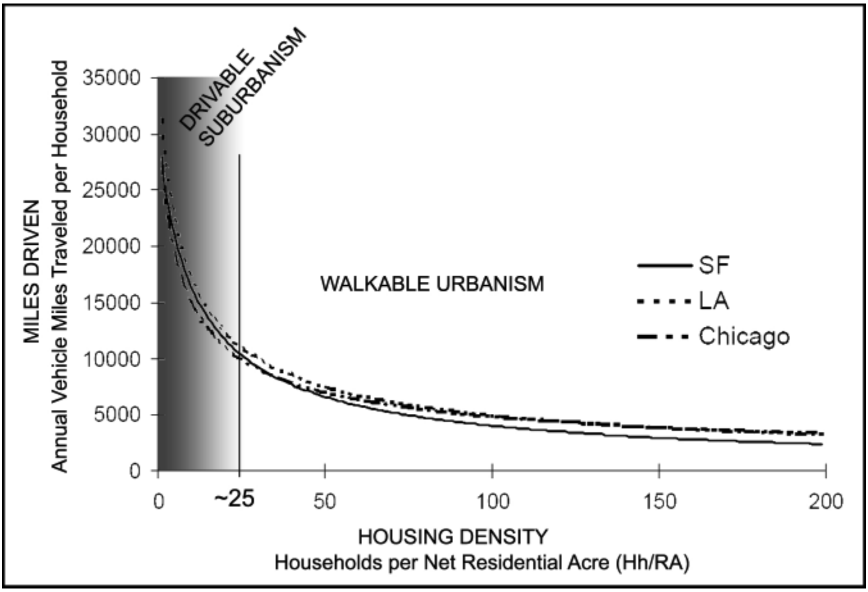


Figure 17: Measurements of housing density and driving distances in San Francisco, Los Angeles, and Chicago reveal an important transition between drivable sub-urbanism and walkable urbanism at a density of approximately 25 households per acre (Source: John W. Holtzclaw. "Smart Growth-As Seen From the Air" June 2000 [Retrieved Oct 2010 from http://www.sierraclub.org/sprawl/transportation/holtzclaw-awma.pdf], p8).

The Smart Growth study identified the following characteristics of development pattern to be significant in determining both auto ownership and driving per household:

**Housing Density**—This factor has the strongest correlation with auto-ownership and driving.
**Household proximity to Public Transit**—As a rule-of-thumb transit access should be within a quarter mile (~5 minute walk) of housing and destinations.
**Pedestrian/Bicycle Friendliness**—Fine-grained street connectivity is extremely important (Figure 13), as well as provision for public sidewalks, design of an inviting streetscape (i.e. with buildings and trees rather than parking lots framing the street corridor), and traffic safety (i.e. traffic-calming narrow streets and bike lanes where appropriate).

Figure 19: The pedestrian-density, mixed use development of Atlantic Station is a contemporary example of walkable urban development supporting both urban civic spaces as well as landscaped park space (Source: VCC General Contractors and The Corwell Group).

Despite the success of many such contemporary urban developments, most Americans have never lived or worked in such places

Walkable urbanism requires a minimum threshold of density with a mix of uses which allows residents to meet their daily needs within a series of walkable districts connected by mass transit. In such places personal automobile use is not a daily necessity. Suburbia, due to its need to accommodate automobile driving and parking, can grow only by consuming ever more land area. As more people move to a suburban area, traffic congestion increases despite constant highway expansion, pollution increases, and open space is dominated by parking lots. As Christopher Leinberger articulates in *The Option of Urbanism*,

> as you build more drivable sub-urban development, you get less quality of life. In other words, more is less. The more that is built, the more the very qualities that attract the households to suburbia are degraded or destroyed, setting the stage for further development on the ever-expanding fringe. The American Dream based upon sub-urbanism is elusive if growth is assumed to continue; the more you build, the more the promise is denied.[35]

Leinberger's insight sheds light on the current proliferation of NIMBY (not-in-my-backyard) attitudes among neighborhood associations and the general distaste for developers. In suburban development, new growth is cheapest and meets the least homeowner resistance on the suburban fringe. Yet as the locus of new development moves outward older suburban and urban neighborhoods and commercial centers are left behind to decrease in value.

By contrast, Leinberger continues, with walkable urbanism, more is better. Adding more density and uses bolsters street life and increases property values and tax revenue. With increasing population densities new amenities such as restaurants and grocery stores can be supported which benefit everyone within walking distance. More housing increases demand for area amenities. With urbanism growth is an "upward spiral of value creation". As long ago as 1961, Jane Jacobs recognized the intrinsic social value resulting from urban areas with a multiplicity of uses and users, which she described in her polemical book, *The Death and Life of Great American Cities*. The vibrancy that is possible in walkable, urban places makes them

35 Leinberger, p130.

increases automobile dependence, and decreases demand for public transit. In short, parking requirements promote drivability and make urban density both less attractive and less affordable.

Figure 21: When parking requirements were adopted in city zoning laws, multifamily apartments were forced to create parking lots, greatly inhibiting their ability to integrate with single-family houses and support an attractive pedestrian-oriented streetscape (contrast this apartment with those of Figure 16).The irony is that such requirements are often desired by homeowners associations to increase on-street parking availability. Alternatively, if housing density is high enough to support walkability, automobiles are not so necessary.

As a sidestep to the limitations of conventional zoning in prohibiting anything but drivable, suburban development, the Planned Unit Development (PUD) arose as a legal process and planning tool which essentially allows developers to sit down with city planners and negotiate the development of buildings which deviated from zoning requirements. This gave developers more flexibility and planners more site-specific control. Since widespread use of the PUD process in the postwar years, it has often been used for mixed-use and mixed-housing developments. Although the PUD process truly calls into question the value of land-use zoning regulation, it has not significantly triggered such a debate. Instead it is simply treated as an alternate method of development where the normally rigid zoning

**19 Standard Real Estate Product Types**

**Income Products**

***Office***
Build-to-suit
Speculative Suburban Low-rise

***Indusrial***
Build-to-suit
Speculative Warehouse (>28' clear span)
Research and Development/Flex

***Retail***
Neighborhood (80 – 120,000 sq. ft.)
Power (120 – 400,000 sq. ft.)
Urban Entertainment

***Hotel***
Limited Service
Full Service Business

***Apartment***
Low-density Suburban (over 150 units @ 15-20 units per acre)
High-density Suburban (over 200 units at over 20 units per acre, stick-built construction)

***Miscellaneous***
Self-storage
Assisted Living

**For Sale Products**

***Residential***
Entry level attached
Entry level detached
Move-up attached
Move-up detached
Executive detached

Figure 26: As real-estate financing has become increasingly dominated by non-local investors seeking only short-term profit, the built environment has become dominated by standardized "real-estate product types" which presume and reinforce drivable suburbanism. Mixed-use buildings necessary to achieve walkable urbanism (and also having much less parking than suburbia would require) can be difficult to finance through such systems (source: Leinberger).

## Transportation

Working hand-in-hand with land-use and density planning, appropriate transportation planning is also necessary to achieve walkable urbanism. Here again, a paradigm shift is necessary at all scales, from national to local, which supports alternatives to personal automobile transportation. More convenient and available mass transit options for intercity and interstate transit, such as high-speed rail, are necessary. Locally, light-rail and bus-rapid transit options which can efficiently serve walkable urban districts are necessary.

Street design must respond not only to automobile use but also to pedestrian and bicycle use (an issue well addressed by form-based codes). Increasing street connectivity is a major imperative and fortunately one which is gaining favor. In early 2009 the State of Virginia passed regulations requiring through-streets linking new development with neighboring development in an effort to increase safety, accessibility and save money.[49] The regulations also require roads to be substantially narrower in order to reduce traffic speeds (thus countering a primary impetus for cul-de-sac development). Worth noting, many walkable urbanism proposals meet resistance when wide streets are required by fire departments insisting it is necessary for one fire truck to be able to pass another fully-deployed fire truck. Yet with highly connected, narrow streets it is possible for emergency vehicles to arrive at a given location by different routes, which can actually increase the response times of emergency vehicles. Further, daily traffic safety is improved as narrow streets naturally reduce traffic speeds.[50]

Obviously there are many details of transportation planning which must be addressed in the transition from suburban to urban development. This work must proceed in concert with zoning reform as an integral part of walkable urbanism.

## Summary

*"Changing the geography of American metropolitan areas will be hard. For one thing, houses last a lot longer than cars. Long after today's S.U.V.'s have become antique collectors' items, millions of people will still be living in subdivisions built when gas was $1.50 or less a gallon."*

-Paul Krugman[51]

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49 Eric M. Weiss. "In Va., Vision of Suburbia at a Crossroads" *The Washington Post*. March 22, 2009; A01.

50 "Designing Streets for Walkability and Safety", *New Urban News*. 2004. p18-19.

51 Paul Krugman. "Stranded in Suburbia" *The New York Times*. May 19, 2008.

# Building Fabric—Past and Present

## The Building Energy Footprint

*"It is not too much to expect that our children will enjoy in their homes electrical energy too cheap to meter; will know of great periodic regional famines in the world only as matters of history; will travel effortlessly over the seas and under them and through the air with a minimum of danger and at great speeds, and will experience a lifespan far longer than ours, as disease yields and man comes to understand what causes him to age. This is the forecast of an age of peace."*

Lewis L. Strauss
Chairman of the Atomic Energy Commission
*New York Times*, August 7, 1955

From such dreamy misinformation Americans have time-and-again allowed themselves to believe that limitless consumption and growth is possible. Yet the reality of fossil-fuel depletion and climate change remain—along with so many other environmental constraints—and the task of immediate corrective action falls squarely on the shoulders of present generations.

The last two chapters revealed how societal energy consumption can be cut roughly in half, while simultaneously improving the livability of cities through walkable urban development. The final chapters of this book examine the next big hole in the bucket—building energy use—and reveals how we can make dramatic reductions in energy use while again simultaneously improving livability, namely through the "Passive House" building standard.

The existing US building stock, including most new buildings being added to it even as this is being written, is among the most energy-intensive in the world. Like our transportation system, our building culture assumes availability of a cheap, abundant, and problem-free fuel supply which simply does not exist.

## How Buildings Use Energy

At the scale of the individual building, energy can be thought of as either embodied or as operational energy. Embodied energy refers to the energy used in the initial production, construction and on-going maintenance and renovation of the building and its materials. Operational energy is the energy used in service of the building's function, from heating and cooling to powering appliances. Of these two, operational energy is generally much greater as shown in Figure 27.

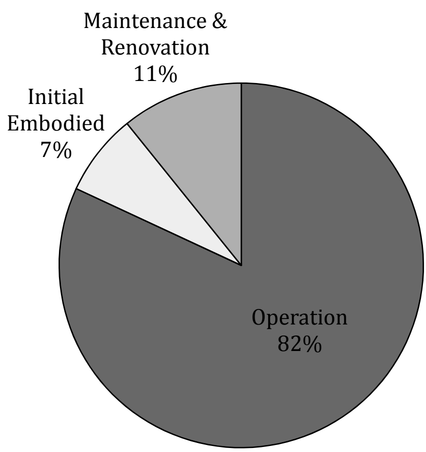


Figure 27: This chart reveals the total lifetime energy use of a three-story office building examined over a 50 year lifespan. The figures are similar for residential buildings. The dominance of operational energy is clear, making this the priority for improvement (data from: Raymond J. Cole and Paul C. Kernan, "Life-Cycle Energy Use in Office Buildings" *Building and Environment*, Vol 31. No. 4. (1996) p310).

The operational energy footprint is further examined in Figures 28 & 29, which categorize the "end-use" of operational energy in US residential and commercial buildings. Significant differences are immediately apparent between the two building types. Residential building energy use tends to be "envelope-driven", meaning that the largest energy loads are caused by energy loss through the enclosing walls, roof, and floor of the building, which cause the large heating and cooling loads shown in the graphs. On the other hand, commercial building energy use is frequently driven by internal loads—mostly lighting and the "other uses" category which includes appliances, equipment, and plug loads. These elements not only consume energy themselves but also give off heat in the building which affects the heating and cooling load (heat gains from occupants can also be significant). If the lighting and "other use" loads are significantly reduced (which is often feasible with modest effort and investment, especially in new construction), internal heat gains will be reduced and the building's energy use may become dominated by the envelope, as it is with residential buildings. Of the two, residential buildings account for the overwhelming majority of the built environment (approximately 74% of the total constructed square footage in the US in 2007)[52] therefore envelope-driven buildings are the focus of this document. As for the architect or engineer whose work is mostly commercial and internal-load driven, the information in this text remains applicable but considerations for daylighting and appliance efficiency, for example, are also important.

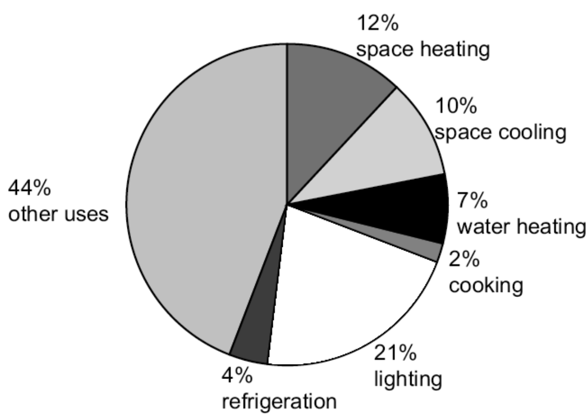


Figure 28: Operational Energy End-Use in Commercial Buildings, 2005. (Source: IPCC "Residential and Commercial Buildings" *Mitigation-Buildings* Ch 6, based on EIA data).

52 Robert A. Murray. "The Construction Outlook: Implications for Architecture Firms" AIA Convention, May 3, 2007.

Figure 30: The first R-2000 home in Newfoundland (1980) utilizes a super-insulated envelope to substantially reduce its heating demand, yet it is indistinguishable from neighboring conventional houses (source: K&P Contracting).

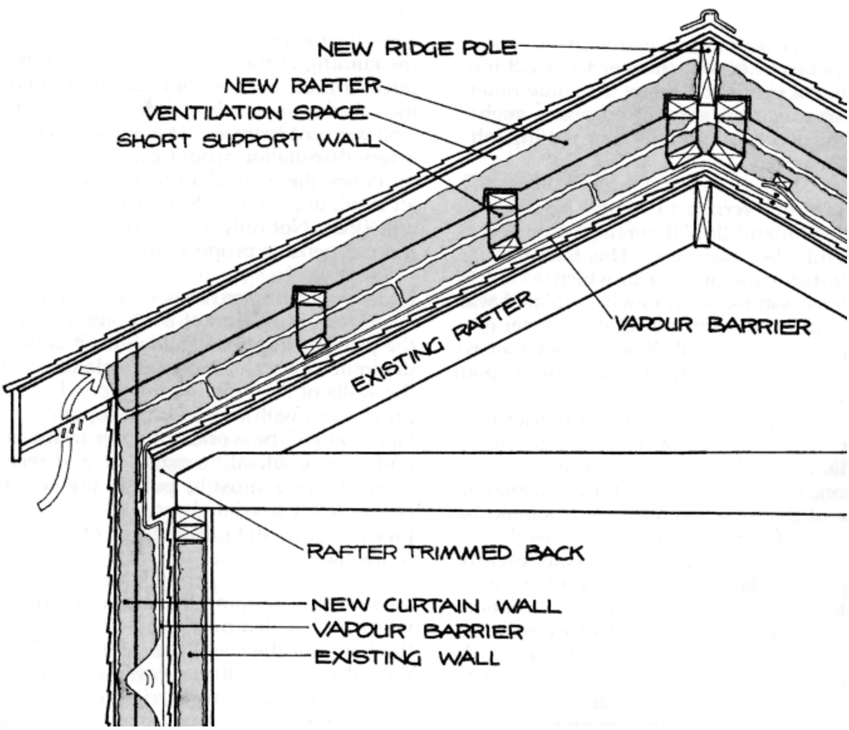


Figure 31: While published in 1981, this detail of a superinsulated building envelope retrofit still today represents the “cutting-edge” (in America) in the advancement of building energy-efficiency (source: Brian Marshall et. al., p58).

Another important result of the 1970's energy crisis was the establishment of energy codes regulating new construction in the US. Notably, the primary focus of the Energy Policy and Conservation Act of 1975 was to regulate the price and allocation of oil. Only three years later was the establishment of building energy codes amended to this bill to promote building energy efficiency.[55] And so again, at a national scale, this unfortunate trend is evident: focusing first on the supply side, before recognizing the need to reduce energy use on the demand side. Unfortunately, creating meaningful progress in energy efficiency through mandatory energy codes has consistently met strong resistance from interest groups such as the National Association of Home Builders (NAHB), whose members presumably fear a loss of profits if such regulations increase the cost of new homes. However, the 2009 American Clean Energy and Security Act (at press time passed by the House and moving through the Senate) currently contains provisions which would require new construction to achieve 30% energy-use reductions compared to current code-equivalent buildings in 2010, and 50% reductions by 2014-2015, and be increased by 5% every 3 years thereafter until 2030. This is a powerful and significant first step toward a fossil-fuel exit strategy. According to the research of the Architecture 2030 non-profit organization, these provisions would save as much energy as would be produced by 600 nuclear power plants, and yet be far cheaper.[56]

## What About "Green" Buildings?

With all of the publicity around "green building" of late, has the situation improved? The value of "green" buildings is as ambiguous as the name implies. The most prominent green building program in the America, the US Green Building Council's "Leadership in Energy and Environmental Design" (LEED) program, has laudable goals, and is certainly increasing public awareness of building-environment issues, but because of its emphasis on marketability, it has greatly limited its actual effectiveness. The source of this problem stems no

55 "History of Codes" Building Codes Assistance Project. [Retrieved on Nov 2009 from http://bcap-energy.org/node/18].

56 Architecture 2030. "Oh, Those Sexy Building Codes" *E-News Bulletin*. No. 16. July 23, 2009.

simply, the program does not facilitate a rigorous method of reducing energy-use. No tools are offered to help architects and engineers collaborate to advance whole-building efficiency, and the energy modeling protocol which is prescribed is not sufficiently rigorous to ensure that predicted energy savings (which is the program's only basis for reward) match actual energy savings once the building is built and in operation. Part of this problem may actually be a result of the limitation of ASHRAE Standard 90.1—one of the standards on which building energy codes are based—which takes no account of building air-tightness.[61] And finally, the training program for LEED accredited professionals is focused on teaching the nuts-and-bolts of the LEED rating system, not on educating building designers about how to design better buildings. These factors must be addressed for the LEED program to truly live up to its name.

Fortunately a much more effective building energy-efficiency program, the Passive House Standard, is now widespread throughout Central Europe and is slowly gaining momentum in the US (this will be discussed in the next chapter). The US Green Building Council would do a great service by adopting the Passive House program as a prerequisite energy performance standard for its LEED program. This would immediately restore its credibility and allow it to continue to do what it does best: marketing.

## Measuring Building Energy Performance

There are several building energy efficiency rating systems and programs in the US, such as Energy Star Homes, HERS (Home Energy Rating System), and LEED (which addresses energy as part of a larger scope). Yet these programs generally share a problem endemic to the field of buildings and energy in general in the US: a lack of standardized and commonly recognized metric by which to measure energy use in buildings. In the US building energy use is measured with various units depending on the energy source and application: units of BTU's or therms or even cubic feet are used for natural gas, kilowatt-hours (kWh) for electricity, and cooling tons for

Institute for Community Solutions, 2009. p9.

61 William B. Rose. Commentary from web log previously cited.

# The Building Fabric of a Fossil-Fuel Exit Strategy

## Conservation and Efficiency

The most cost-effective priority to reduce fossil-fuel consumption is to reduce demand through conservation and efficiency.[62,63] Only once demand is substantially reduced does it become cost-effective to consider investment in renewable, carbon-neutral fuel supplies.

Conservation is an old-fashioned value destined to return. Valuable lessons were learned by the generations that lived through the Great Depression. Simply put, conservation is the cheapest and easiest way to dramatically reduce your carbon footprint. When an avalanche disabled much of Juneau, Alaska's access to their hydroelectric power in April 2008, electricity rates rose by 400%. Within weeks the average household energy consumption had dropped by 38% as people began conserving their use of hot water, clothes dryers, and the like.[64] Additionally adopting a conservative attitude is important because without it, efficiency can actually lead to increased energy consumption when the money saved from an efficiency upgrade is then simply directed toward other more energy-intensive activities.

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62 "The Impact of Federal Energy Efficiency and Renewable Energy R&D Programs". Hearing before the Subcommittee on Energy, Committee on Science, House of Representatives, 108th Congress, 2nd Session, May 19, 2004. Serial No. 108-59. p4.

63 M. Levine, D. Ürge-Vorsatz, K. Blok, L. Geng, D. Harvey, S. Lang, G. Levermore, A. Mongameli Mehlwana, S. Mirasgedis, A. Novikova, J. Rilling, H. Yoshino. "Residential and commercial buildings". Climate Change 2007: Mitigation. 2007. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. p393.

64 "Juneau Residents Drastically Reduce Energy Use" Energy Design Update. Aspen Publishers. July 2008, p8.

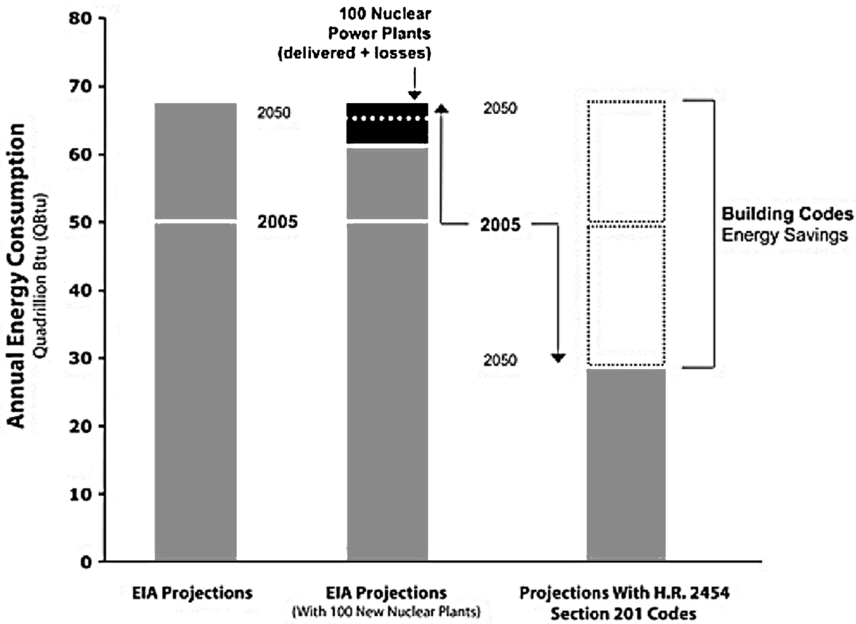


Figure 33: U.S. Building Sector Energy Consumption Projections 2005-2050. Expanding energy supply through significant nuclear power investment (column two) increases both energy demand and carbon emissions by 2050. Conservation and efficiency brought about through the aggressive building energy codes proposed by the Waxman-Markey Climate Bill (column three) reduces both energy demand and carbon emissions significantly (Source: Architecture 2030, data from EIA).

Conservation and efficiency are clearly the most effective, the cheapest, and the quickest means to realize substantial reductions in fossil-fuel demand and carbon emissions. Quite simply, we cannot afford to meet the energy demand of our present poorly-insulated building fabric with renewable energy. We can however invest in a radically more energy-efficient building stock so that present and future generations may have the opportunity to maintain contemporary comfort standards without dependence on fossil-fuels and without furthering climate change.

## Strategy and Regulation

Just as conventional zoning laws compel automobile use, current building energy codes compel the market-driven building industry to produce buildings with excessive energy demand. Building codes exist with the intention of protecting public health, safety and welfare. Yet the definition of "public" has been limited to a consideration of building occupants, and as David Eisenberg, director of the Development Center for Appropriate Technology, points out, this comes to the detriment of the public at large:

> If, inadvertently, the codes are actually jeopardizing the health and safety of everyone on the planet by ignoring their impacts on resources and the environment, resulting in the destruction of the ecosystems that sustain us, we are obligated to re-invent the codes with that larger perspective… This is at a point when only two billion of the nearly six billion people on the planet live and work in modern resource-intensive buildings. The projection is that in fifty years, it will be four times that many. (Figures from [1995] Worldwatch Paper #124.) Apply the level of resource intensity that is, essentially, required by our modern building codes in the US to the world population and it is apparent that it's not even remotely possible to house that number of people in this manner, with the available resources.[68]

The establishment of energy codes in the 1970's was a first step toward an expanded sense of public welfare, but until these codes base their standard on a fossil-fuel exit strategy with a time-table for ending climate change they fall short of their imperative to protect public welfare.

Just such a strategic basis is offered by the Architecture 2030 Challenge issued by the non-profit research group Architecture 2030, led by architect Edward Mazria. The 2030 Challenge, which is adopted on a voluntary basis, specifies energy-use reduction targets for both new and retrofit construction which start at 50% energy-use reduction and ratchet up every five years to achieve net-zero-energy,

68 David Eisenberg. "Sustainability and the Building Codes" The Last Straw: The Grassroots Journal of Straw Bale and Natural Building. Issue #24, Winter 1998-99.

Much could be said about any one of these categories but the biggest priority for building professionals, and perhaps the most difficult to achieve, is substantially increasing the efficiency of the building envelope. This is true for several reasons. The building envelope is the biggest component of a "building" and thus it affects and is affected by virtually all participants in the building design and construction process. Changing the conventional building envelope requires motivation, effort, and collaboration. Additionally, realizing significant envelope efficiency has a window of opportunity limited to a major construction undertaking. By contrast, appliance efficiency upgrades or active renewable energy systems can be added more easily outside of such an undertaking. For this reason construction projects should prioritize envelope efficiency (based on an energy reduction target tied to a climate change remediation schedule) in order to establish the requisite infrastructure to make true sustainability possible.

The remainder of this chapter takes a more in-depth look at one of the world's most ambitious and successful building energy efficiency standard, the Passive House Standard.

## Envelope Engineering: The Passive House Standard

The Passive House Standard has resulted in hundreds of the most energy-efficient buildings in the industrialized world, from the first set of Passive House row-houses built in 1990 in Germany (Figure 35) to the first high-rise office tower built to the Passive House Standard completed in Linz, Austria in 2009. In German, "passivhaus" means literally, "passive building" and as such the Passive House methodology applies to all building types, and centers on the concept of maximizing investment in passive energy-efficiency measures (i.e. insulation and airtightness) in order to minimize investment in active energy use (i.e. heating systems) (Figure 36). The cost-effectiveness of this approach increases at a critical point where heating loads are cut by 80 - 90% and a conventional heating system is no longer necessary. In such cases a Passive House residence can often be heated with the equivalent of a hair dryer, and this heat can be supplied by the low-flow ventilation air supply which is necessary in any case. The Passive House Standard is defined by specific energy-use and envelope performance targets which were derived from this concept (Figure 37). As such it is a completely performance-based standard which makes no prescriptive requirements such as material choice.

Figure 35: The first Passive Houses, a series of four rowhouses, were built in Darmstadt, Germany in 1990 (photo by the author).

To enable building designers to predictably meet these ambitious performance requirements, an energy modeling software was developed specifically for the rigorously efficient standard: the Passive House Planning Package (PHPP). While the software's spreadsheet platform is quite simple, the program is actually much more rigorous than typical energy modeling programs because it is tailored to the detailed conditions of a highly insulated, thermal-bridge-free building enclosure.[69] For example, the PHPP requires very detailed data entry concerning windows, including glass conductivity (*U*-value), frame conductivity, as well as the conductivity of the spacer used

69 Wolfgang Feist, et al. *Passive House Planning Package 2007: Specifications for Quality Approved Passive Houses*. Passivhaus Institut, 2007.

Figure 36: Comparing a Passive House building to a conventional building is analogous to comparing an insulated thermos (left) to a coffee carafe on an active burner (right). Through continuous insulation and air tightness the thermos passively conserves the coffee's heat whereas the open carafe requires active heating to keep the coffee hot. The infrared image (at top) shows the stark difference in heat loss between the two containers. The concept applies the same for conserving air-conditioned cooling as well (Source: Passivhaus Institut).

between panes of glass and the conductivity of the thermal bridge that occurs between the window and its host wall. Such detail allows accurate energy predictions to be made of buildings with such a radically minimized heating demand. In addition to the submission and review of PHPP modeling results for a given building design, a any building, but obviously this is not recommended when it is cold outside). In the United States one to two dozen Passive Houses have been constructed and many more are under construction at the time of this writing (including at least one school and one commercial building).[71]

Figure 38: The Energon office building—an 86,000 square foot Passive House in Ulm, Germany built in 2002.

Because Passive House buildings have such an efficient well-engineered envelope, the majority of their heating demand can be met with passive solar heat and internal heat gains. In fact, during power outages in which supplemental heating is not functioning, even in the middle of winter, with normal occupancy a Passive House will not drop below 54-59°F.[72] Thus power outages are not debilitating or life-threatening in a Passive House. But beyond mere survivability, Passive Houses are extremely comfortable. Interior surface temperatures are much warmer than in conventional houses, reducing cold sensations near windows for example, and interior temperature distributions are quite even. With continuous, filtered ventilation,

71 Mary James. *Recreating the American Home: The Passive House Approach*. Low Carbon Productions, 2010.

72 Helmut Krapmeier and Eckart Drössler ed. *CEPHEUS—Living Comfort without Heating*. Vienna: Springer-Verlag, 2001.

## Passive House Design

Sheltering ourselves on this planet sustainably, and specifically, meeting our contemporary comfort standards with renewable energy resources, requires calling some standard assumptions into question. With this appreciation the design of a Passive House building should begin. Most importantly, the basic geometry of the building's thermal envelope should minimize its exposure to the environment as appropriate in a given climate. This is most critical with single-family detached houses, which quickly become impractical as Passive Houses as geometric complexity and exposure increases. With attached housing and commercial buildings more flexibility is possible, and compactness must be balanced with considerations for daylighting and natural ventilation, for example. Window design is highly critical in all Passive House designs. Because of the relatively low-insulating value (low R-value) of even triple-pane windows as well as their propensity to accept solar heat gains (desired or not), and also because of their affect on electric lighting loads, windows must be strategically placed, sized, and shaded, and contain glazing with optimum properties (a balance of U-value, solar heat gain coefficient, and visible transmittance). The Passive House planning software is an indispensable design tool in this regard.

The basic elements of a Passive House building are summarized in Figure 40 and further described herein.

**Superinsulation**—A Passive House building is defined by a continuous, highly insulated thermal envelope. In plan and section views of a building, the designer should be able to trace along this envelope without picking up her pen. The thermal envelope cannot be significantly compromised by thermal bridging—a "thermal bridge" is any significant lapse in insulation levels caused by a conductive material such as metal or concrete which penetrates the thermal envelope. All junctions such as between the ground condition (i.e. floor slab, basement, etc.) and exterior walls, and walls and roof, etc. must be continuously insulated. Windows and doors must also be highly insulating (i.e. triple-pane windows with insulated frames) and installed in a manner that limits thermal bridging around their perimeter. Indeed few such windows are available in the US that would meet Passive

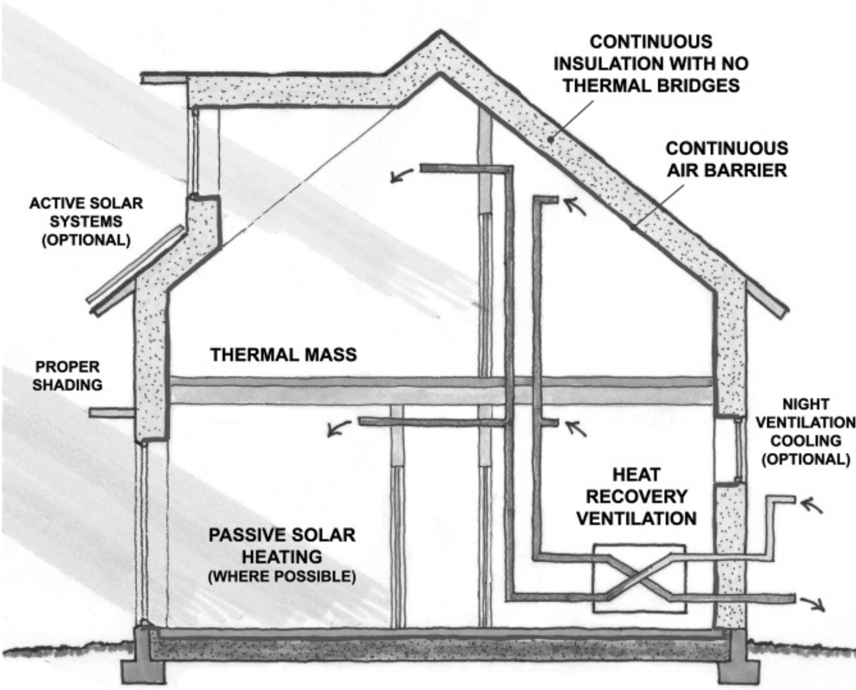


Figure 40: Basic principles of Passive House design: minimizing energy use while maximizing livability.

House certification requirements for U-value and air-tightness, although they are common throughout Europe. One example of a Passive House envelope assembly is shown in Figure 41, however the Standard makes no prescriptive requirements that certain materials or construction methods be used.

**Airtightness**—Also defining the thermal envelope of a Passive House, running alongside the insulation, is a continuous air barrier. This air barrier must be carefully designed and constructed to achieve an unprecedented degree of air-tightness—0.6 $ACH_{50}$ (air changes per hour under 50 pascals of pressure). By comparison many common buildings are on the order of 20 $ACH_{50}$ and even many "tight" buildings are not less than 5 $ACH_{50}$. In the US housing industry air-tightness efforts often do not go beyond this point because doing so makes mechanical ventilation necessary, increasing initial costs. Even among the ambitious housing projects which have transgressed this boundary (for instance some projects of the US Department of Energy's "Building America" program) air-tightness beyond approximately 2 $ACH_{50}$ is rarely achieved. Critics suggest that going beyond this, to achieve the Passive House Standard of 0.6 $ACH_{50}$ requires a very simple building form (increasing the number of corners makes air tightness more difficult).[74] Such claims deserve consideration, yet many Passive House buildings abroad have been realized which exhibit no geometric restraint and are indiscernible from their conventional counterparts. The additional benefit of such a stringent air-tightness standard is increased durability, due to the lowered risk of air infiltration carrying moisture into wall and roof assemblies.

This air-tightness standard must be verified during construction through the use of a "blower-door" test (Figure 42). This on-site testing has the additional effect of directing attention to the construction process to ensure the designer's details and specifications are properly constructed.

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74 John Straube. "The Passive House (Passivhaus) Standard: A Comparison to Other Cold Climate Low-Energy Houses" *Insight*. No. 25. October 2009. www.buildingscience.com.

Figure 42: A “Blower-Door” test is required during and after construction to verify the rigorous airtightness requirement has been achieved (photo courtesy of Green Hammer).

**Heat-Recovery Ventilation**—With such a tight envelope in a Passive House, mechanical ventilation must be supplied, and to minimize energy losses a balanced heat-recovery ventilation system is used to recover at least 75% of the energy of the exchanged air. A conceptual diagram of a typical residential system is shown in Figure 44. The ventilation air typically flows constantly at low flow rates (or in response to occupancy in commercial buildings). This air flow is generally imperceptible to occupants, being much slower and quieter than conventional forced-air systems. And yet the heat load is so small in Passive Houses in moderate climates that heating can often be distributed with this low flow-rate of air. Further because the envelope of a Passive House is so well insulated, the interior surface temperatures of walls and windows are high enough that heating does not have to be actively supplied in their proximity to maintain and obstructions. Shading is particularly critical in climates with significant cooling requirements.

**Passive Solar Heating**—In residential Passive Houses, solar heat is often the largest heat source. However passive solar heating is not absolutely necessary to achieve the Standard—the energy modeling software can be used to find ways to compensate if solar access is unavailable. The properties of windows of different orientations (i.e. south vs. west) can be tuned and modeled in the PHPP to ensure optimum performance.

Figure 45: As this Passive House residence nears completion, an overhanging trellis is installed to allow vegetation to provide seasonal shading of its south-facing windows (photo courtesy of Robert Hawthorne).

**Thermal Mass**—A considerable amount of mass in the building's interior (i.e. concrete, drywall) is useful to prevent overheating of Passive Houses, especially when significant solar heat gains or internal heat gains occur. Dynamic energy modeling and field studies have found that, due to the subtle air circulation provided by the continuous ventilation system of Passive Houses, it is not necessary to place thermal mass in direct proximity to south-facing windows. Instead it efficiency before investments in less cost-effective (but visible/marketable) renewable energy systems are made. This source-energy requirement has the effect of ensuring that not only is the envelope highly efficient, but that other energy end-uses such as hot water heating, lighting and appliances are also highly efficient, and the energy supply used to meet demand is also appropriate. The PHPP modeling tool is used to gather all such data to aid cost-optimized achievement of the Passive House Standard.

**Renewable Energy Supply**—With total building energy loads reduced by as much as 70% in a Passive House, it becomes far more cost-feasible to supplant fossil-fuels with renewable energy. Biomass, solar-thermal, solar-electric, and wind generators offer the potential to realize carbon-neutral building operation. If the construction budget is exhausted by the Passive House implementation, such systems can be added at a later time (much more easily than vice versa).

Figure 46: This four-story duplex currently under construction in Portland, Oregon both increases housing density and meets the Passive House Standard, and will tremendously decrease the carbon footprint and fossil-fuel dependence of the residents.

# Conclusion

The fossil fuels which triggered and sustain modern industrialized society will soon decline. The climate-change consequences of fossil-fuel combustion grow more threatening day by status-quo day. Successfully navigating these unprecedented challenges, as lessons from history suggest, requires that we develop sound long-term planning and also reassess our core values to meet present circumstances.

Fundamental to long-term planning is the revision of public policies and development practices which produce the fossil-fuel-dependent built environment we now live in. Through a paradigm shift in where, what and how we build, we can effect radical reductions in carbon emissions and begin to realize a modern human habitat that does not require fossil-fuel inputs. This is the basis of a fossil-fuel exit strategy.

Parallel with this technical planning, consideration of our core values is necessary. Common American values of individualism and libertarianism were forged in the fight for political and religious freedom from an oppressive central authority. Yet the greatest threat to America, to humanity and the natural world, is now self-induced through our proclivity for energy-intensive lifestyles and exacerbated by our more recently adopted materialistic values. Avoiding the "tragedy of the commons" requires recalibrating our values to support collective, cooperative problem-solving. We should recognize that "progress" in a paradigm of *unchecked* consumption and growth, is impossible. "Progress" should instead shift toward a paradigm of cultural growth focusing on quality-of-life rather than a material standard of living. Working toward societal success, we have the opportunity to realize a more rewarding pursuit of happiness. Through such value shifts, necessary policy changes may more appropriately and swiftly arise.

With the advent of industrialization, centuries-old patterns of walkable urbanism were abandoned in an attempt to cope with industrial pollution, support socio-economic segregation, and later, to more fully accommodate the automobile. Conventional zoning segregating

# Appendix

Impacts of Climate Change

Charter of the New Urbanism

Carbon Tax & 100% Dividend

# About the Author

Dylan Lamar is an architectural designer and building-energy consultant at Green Hammer, an integrated design, construction and energy-efficiency consulting company in Portland, Oregon. He holds degrees in civil/structural engineering and architecture. His graduate studies, centered on sustainable architecture, also included advanced coursework in the field of urban design and planning. He is a certified Passive House consultant, and has been involved with Passive House design since 2004 when he was a student intern with the organization now known as the Passive House Institute US. He currently lives in Portland... and enjoys walking home for lunch.

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