SITE PLANNING AND LOCAL GOVERNMENT STRATEGIES FOR CONSERVING
ENERGY AND PROMOTING RENEWABLE ENERGY

by

Justin Sabrsula

A Master’s Project submitted to the faculty
of the University of North Carolina at Chapel Hill
in partial fulfillment of the requirements
for the degree of Master of Regional Planning
in the Department of City and Regional Planning.

Chapel Hill
2006

Approved by:

__________________________________
ADVISOR
ABSTRACT

JUSTIN SABRSULA: Site Planning and Local Government Strategies for Conserving Energy and Promoting Renewable Energy (Under the direction of Raymond J. Burby)

Energy consumption from the built environment creates increasing impacts on the natural environment in forms of air pollution and global climate change. Through site planning for energy conservation, planners can dramatically reduce the energy consumption of buildings in the urban environment. Techniques such as passive solar orientation, landscaping for energy conservation, green building guidelines, and increasing building density all individually reduce energy consumption and when combined interact to compound energy savings. Additionally, by providing access to renewable energy supplies such as wind and solar energy, planners can enable community solutions to energy problems.

Government actions often lead the way in proving energy conservation principles, and renovating existing buildings will play an important role in reducing urban energy consumption. Through a combination of more energy-efficient site planning processes and government actions, cities can consume dramatically less energy, creating a more efficient urban area which minimizes its impact on the atmosphere and global climate change.
ACKNOWLEDGEMENTS

To the casual observer, a master’s project may appear to be solitary work. However, to complete a project of this magnitude requires a network of support, and I am indebted to many people. My advisor, Ray Burby, helped me focus my thoughts and constructively critiqued the content and structure of this paper. I am thankful for my great friends Mary Donegan, Annie Lux, John Miller, Chris Norman, and Emily Snyder for lending a sympathetic ear for my moaning about this project. I am most especially grateful to my parents, Dub and Kara Sabrsula, for their guidance, support, both monetary and otherwise, and their love and understanding during the past six years I’ve been in school. I promise to get a job after this project is completed.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF FIGURES AND TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Global and national level context</td>
<td>1</td>
</tr>
<tr>
<td>Site planning and government strategies</td>
<td>3</td>
</tr>
<tr>
<td>II. SITE LEVEL SOLUTIONS</td>
<td>4</td>
</tr>
<tr>
<td>Passive Solar Orientation</td>
<td>7</td>
</tr>
<tr>
<td>Landscaping and the Urban Heat Island effect</td>
<td>12</td>
</tr>
<tr>
<td>Green Building guidelines</td>
<td>16</td>
</tr>
<tr>
<td>Active solar: solar photovoltaics and solar water heaters</td>
<td>21</td>
</tr>
<tr>
<td>Dwelling type and density</td>
<td>25</td>
</tr>
<tr>
<td>III. OTHER IMPLEMENTABLE MEASURES</td>
<td>27</td>
</tr>
<tr>
<td>Governments leading the way</td>
<td>28</td>
</tr>
<tr>
<td>Weatherizing and insulating existing buildings</td>
<td>30</td>
</tr>
<tr>
<td>District heating and combined heat and power</td>
<td>32</td>
</tr>
<tr>
<td>IV. CONCLUSIONS</td>
<td>34</td>
</tr>
<tr>
<td>V. WORKS CITED</td>
<td>37</td>
</tr>
</tbody>
</table>
LIST OF FIGURES AND TABLES

Table 1: Settlement Characteristics Affecting Energy Consumed for Transportation and Space Heating........................................................................................................................................6

Figure 1: Passive Solar Design ..................................................................................................................................................................................8

Table 2: Passive Solar Orientation Recommendations ..................................................................................................................................11

Table 3: Overview of Seattle’s 1975-1977 Energy Conservation Programs ........................................................................................................29

Figure 2: Energy Efficiency Comparisons .........................................................................................................................................................33
INTRODUCTION

In many cities in the United States, concerns about urban energy consumption or renewable energy technologies have not been raised in at least 25 years. With the resumption of dramatically higher coal, natural gas, and oil prices, concerns about global peaking of oil supplies within five to thirty years, and growing concerns with global warming caused by energy consumption, cities stand on the cutting edge of efforts to reduce energy use and greenhouse gas emissions. Over the past five years, cities have increasingly taken action to reduce energy use and greenhouse gas (GHG) emissions from municipal services. Cities, with few exceptions, have not examined the effects of comprehensive site-level and neighborhood-level land use planning on energy conservation and renewable energy supplies. With mounting stresses on energy security and the atmosphere caused by growing energy consumption, local governments, and especially those with municipal utilities, have an important role to play in reducing energy consumption through land use planning.

Global and national level context

Urban areas house the majority of global population and are where most global energy consumption occurs. From 1800 to 2000, the percentage of world population increased from 3 percent (25 million people) to more than 50 percent (3.3 billion people). This urbanizing trend will only hasten in coming years, as “urban areas are growing three times faster than their rural counterparts. Ninety percent of the expected population increase in the next two decades will occur in cities” (Pinderhughes, 10). The increase in population in urban areas in the developing world and the increasing prosperity in the developed world require large numbers of new buildings to be constructed, all of which consume energy on some level. Unfortunately, “the vast majority of modern buildings worldwide are built
without regard to working in tandem with nature; consequently, they neglect the importance of climate and light and do not take advantage of appropriate technologies” to reduce energy consumption throughout their operating lifetimes (Pinderhughes, 102). Pearson notes that “with central heating and air conditioning, siting the house in relation to its locality no longer seems to be so important. But, with the increasing pressure on world energy resources, these commonsense considerations are again becoming basic requirements” (85).

Indeed, while buildings do not consume the majority of energy in the United States, their energy consumption comprises a significant proportion of U.S. energy demand, including “65 percent of total U.S. electricity consumption, ... more than 36 percent of total U.S. primary energy use, and ... 30 percent of total U.S. greenhouse gas emissions” (Pinderhughes, 103). This energy consumption comes at a large cost to building users and homeowners. Even without accounting for the costs of greenhouse gas emissions or the large rises in energy costs in the past seventeen years:

“In the United States, in 1989, buildings used $200 billion worth of energy just for basic lighting, space heating and air conditioning, which is more than was used by the industrial processes and transportation. Of this total, residences used $120 billion and the balance was attributed to commercial buildings, including offices, shops, school and hospitals” (White, 97).

Through comprehensive land use planning, municipal governments can influence energy consumption at numerous levels. Regional-level land use planning may perhaps provide the most overall impact in reducing energy use through altering urban form and transportation patterns. Through altering connections between land use and transportation, city planners can reduce transportation energy consumption by creating an urban form conducive to pedestrian and cycling activity and use of public transportation, which are less energy intensive than reliance on personal automobiles. Unfortunately, such policies are the
least likely political solution to solving energy problems through land use planning, and given the scale of the changes needed to truly alter American urban form, are beyond the scope of this paper.

**Site planning and government strategies**

Local governments, however, adopt site-level and neighborhood-level land use planning policies on a regular basis. By enacting policies which encourage or require energy consumption to be accounted for in the site planning process, energy conservation in cities can begin without challenging large-scale urban form. Calthorpe provides a view of strategies for energy conservation planning, including:

“reduced auto usage, enhanced microclimate, conservation in buildings, and climate-responsive architecture. Interestingly, they tend to overlap and reinforce one another. For example, an enhanced microclimate, through shade-trees or wind barriers, can affect auto usage by creating more comfort for the pedestrian, and simultaneously eliminate the need for architectural shading. Climate-responsive buildings, with courtyards for thermal buffering or clear glass for daylighting, can add interest and safety for the pedestrian and avoid the negative microclimate impacts of reflected glare or wind tunnel effects. Reduced auto usage can have a positive impact on building energy consumption by reducing asphalt areas and the associated heat buildup. This interaction of effects means that a careful balancing of strategies, appropriate to the climate and region, is important” (Calthorpe, 75).

At the site and neighborhood level, layout and solar orientation of sites and subdivisions, providing a mix of land uses, encouraging increased supplies of various forms of alternative energy and, under conducive environments, utilizing combined heat and power plants can reduce energy needed for cities, increase the efficiency of the energy that is used, and increase alternative energy supplies. On the site level, planners can influence energy consumption through site planning to emphasize energy conservation, including passive and active solar building design, green building guidelines, microclimate influences through landscaping and reduction of impervious surface, and modernizing insulation in buildings. In
many cases, due to the interactive nature of many of the energy conservation measures and the importance of local climate and microclimate considerations, planners should avoid prescriptive measures in favor of performance-oriented energy consumption standards. Pearson recognizes that the most efficient site design “will vary from one climate region to another. The main aim is to make the best possible use of natural features – trees, land forms, and local winds and water – for warmth and shelter, and thereby reduce the need for artificial forms of heating, cooling, and insulation” (85). In this way, a builder or developer “is allowed to experiment and to innovate. ... [G]reater effort should be made to ensure that energy management was acceptable to all those involved in the development process, including the eventual homeowner” (Sewell and Foster, 28). Taken as a suite of policies and decisions, site and neighborhood planning initiatives can result in dramatic reductions in energy use for residential and commercial uses in cities across America.

SITE LEVEL SOLUTIONS

Site planning in urban areas determines the nature of urban space. Wikipedia describes the process of site planning as “the organization of land use, access, circulation, privacy, security, shelter, land drainage and other factors. This is done by arranging the compositional elements of landform, planting, water, buildings and paving” (1). While land use zoning dictates the uses a particular parcel of land can accommodate, site planning reviews and charrettes in the urban planning process increasingly determine the character and nature of urban space. Through adequately considering energy conservation and alternative energy sources in the site planning process, urban planners can influence energy use at the city level.
Two interacting variables at the site level determine energy use: building design and site design. Buildings primarily consume energy in operating over time, and green building codes offer a simple way to reduce energy consumption from operations. Cities across the country, including Austin, Texas and Boulder, Colorado, have successfully implemented green building programs to help reduce energy consumption on the building level. Additionally, national organizations such as the United States Green Building Council have introduced green building certification programs (e.g. LEED - Leadership in Energy and Environmental Design) to achieve similar reductions in building energy consumption through a variety of systems.

Green building codes provide ready reductions in energy consumption from buildings, but site design can compound those reductions. In addition, orienting buildings to take advantage of active and passive solar energy, along with other site planning characteristics affecting microclimate reduces energy consumption and can increase provision of alternative energy supply. Depending on local climate, landscaping for shading or wind-breaking purposes, along with orienting buildings to capture local winds aids in green building design and reduces heating and cooling needs for the building. Moughtin and Shirley describe how it is important “to relate buildings to the local environment and particularly to the local climate: for example, in a cold climate to insulate the building effectively; to reduce to a minimum the amount of external wall surface; to orientate the building towards the sun; to provide a buffer on the cold north face; and to build conservatories on the sunny facades” (226). In addition, building form, layout, and density on the site determine how much energy the building will use, “since the basic energy requirements of a building are determined by its surface area to volume ratio. Siting and
orientation have important energy implications since they can be used to gain advantage from microclimatic factors and from ‘free’ ambient energy sources” (Owens (b), 41). As Priest, Howland, and Byrne point out:

“optimum siting and site planning may be more important and, in most cases, less expensive than architectural or mechanical solutions in solar radiation utilization and in energy conservation ... Solar incidence, wind velocities and directions, and variations in microclimates as a function of topography and vegetation are the important climatic variables. Energy-conscious site planning will allocate gross land uses to minimize or maximize natural forces and it will configure and orient the individual structures to take the best advantage of their specific sites and lots. Energy-conscious site planning also requires that the shading and wind pattern effects of the buildings to be constructed be taken into account” (238-239).

On a larger level, “orientation, layout, and density also facilitate or prejudice the introduction of district heating networks. In short, spatial structure at the local scale both influences energy demand and to some extent dictates which energy-conserving technologies are feasible” (Owens (b), 41). Table 1, adapted from Sewell and Foster, demonstrates the scale and type of site planning attributes which affect energy consumption.

<p>| TABLE 1: Settlement Characteristics Affecting Energy Consumed for Transportation and Space Heating (Sewell and Foster, 71). |</p>
<table>
<thead>
<tr>
<th>Settlement Characteristics</th>
<th>Transportation</th>
<th>Space Heating</th>
<th>Macro Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall structure and configuration</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Mix of uses</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Local pattern</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Siting and landscaping</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Building form</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Roadblocks to reducing urban energy consumption, however, provide pause concerning the ease with which many of these changes can be achieved. In many areas, zoning and planning controls prevent energy-conserving development from occurring. Among the restrictions are strict setback and side and rear yard requirements and provisions which require houses to be oriented to the street, large minimum lot sizes, and restrictions on
taking advantage of topographic features of a site, all of which limit pioneering site designs that reduce energy consumption. Conventional Euclidian zoning may also prevents the mix of uses and densities of housing which conserve energy (Priest, Howland, and Byrne, 238-248). Finally, planners will struggle to encourage energy conservation among competing priorities for attention. As Banister points out, “if energy use is the only variable to be considered, then ideal patterns can be established, but in most cases one is dealing with an established settlement pattern and any radical change to that system has to take account of the complex interactions between transport, land, labour, and capital, and the time required for any change” (174).

In examining the role of differing strategies for reduction in urban energy consumption and increasing the use of alternative energy sources, this paper will explore different technologies, discuss drawbacks to each technique and conflicts with other technologies and techniques, and provide pertinent policy examples to provide an overarching view of how cities can plan for energy conservation and alternative energy supplies at site and neighborhood levels.

**Passive Solar Orientation**

Correctly orienting residential and small commercial buildings to capture solar energy at the site level presents the most direct method for urban planners to reduce energy consumption at the site and neighborhood level. Orienting buildings for passive solar heating of buildings “uses the architecture of the structure to reflect heat from sunlight in the summer and absorb it during the winter. Effective use of this technique combined with proper ventilation can remove [or reduce] the need for any heating or cooling system in a building” (Pinderhughes, 106).
As Wheeler explains, utilizing passive solar design begins with simply being aware of what direction is south (north in the Southern Hemisphere) and orienting buildings in that direction to capture as much solar energy during winter months as possible while using other landscaping and architectural features to shade the buildings during summer months (225). Owens notes that “the use of passive solar energy can lead to significant savings in conventional fuel at little or no economic or environmental cost: demonstration projects in Milton Keynes in the United Kingdom suggest that in the ‘ideal’ situation (passive solar houses on an ideal site) energy demand for space heating might be reduced by 11-12%” (Owens (a), 83).

**Technical difficulties:** With impressive reductions in energy use such as this, passive solar houses enjoyed significant popularity during the energy crises of the 1970s. However, initial experiments with passive solar architecture in the 1970s produced some homes which had problems with overheating during the summer. However, Crawford notes that design and construction techniques have been refined for homes since that time, and despite the fact that “construction costs are higher than for conventional buildings[,] the extra expense seems to be justified, even at current energy prices” (115-116).
Despite the many benefits of orienting buildings to take advantage of passive solar heating, planners have shied away from implementing subdivision ordinances which require passive solar orientation of sites and neighborhood developments because of perceptions about limitations on residential densities, shading, topographical problems with correctly orienting streets east-west so that building lots face south, or some combination of these factors. Owens, however, observes that these fears are in many cases overstated:

“The orientation requirements and the need to avoid overshadowing might seem to imply that the use of passive solar energy would be compatible only with relatively low housing densities. ... However, recent research suggests that there would not be difficulties below densities of about 30 dwellings per hectare [12.1 dwellings per acre], and even at densities of around 40 dwellings per hectare [16.2 dwellings per acre], loss of solar radiation need not be more than 20%. ... Nor are the orientation criteria very rigid; there is a good tolerance limit of 30-40° variation from a north-south axis within which advantage can be taken of solar gain” (Owens (b), 46).

Indeed, Owens notes, most greenfield sites will have little trouble meeting solar orientation guidelines given proper attention to design. Problems will arise, however, with urban infill sites where higher densities are expected to be developed, and existing buildings may cast shadows over the site (Owens (a), 83).

Policy Implementation: Through subdivision regulations requiring south-facing lots and appropriate street layouts and establishing solar access, as well as using familiar planning tools such as setbacks and height controls, planners can ensure that solar access is available to individual lots and neighborhoods. Solar access law, though in many cases forgotten after the energy crises of the 1970s, has been well established in many states. In order to promote energy conservation through passive solar orientation land use regulations, Kaiser, Madsen, and Burby advocate for the following changes to subdivision and zoning practice:

“as a start, the states could amend their subdivision regulation enabling legislation to make energy conservation a valid purpose of subdivision regulation. Second, model subdivision regulations incorporating various passive solar energy and other
‘neighborhood’ energy-conservation concepts could be developed and promoted among local government officials in a state, along with documentation of energy savings possible through passive solar design. Third, building codes could be amended so that builders were required to consider the potential for passive solar energy in the orientation of housing units, design of roof overhangs, size and location of windows, use of landscaping, and other characteristics of residential sites and structures” (304).

In the wake of these recommendations, several cities and states across the country adopted passive solar orientation regulations and recognized protection of solar access as a legitimate government purpose. New Mexico’s Solar Rights Act of 1978 allowed property owners to claim solar rights and create solar easements, and also reserved the right of local governments to create ordinances or zoning rules to govern the creation of solar easements, though none did so (DSIRE, 1). Indeed, Hayes points out, “zoning already regulates many particulars of property development that are key to solar access: the maximum height of structures; the distance that they must be set back from the front, side, and rear boundaries of their lots; their orientation; what accessory structures are allowed and where they may be put; and the permitted uses in each area” (74). Erley and Mosena advocate for subdivision regulations which force developers to run streets east to west, with lots running north to south, as well as developing south-facing slopes first to optimize passive solar orientation in subdivision developments (466). Several cities actually implemented changes to subdivision regulations in the 1970s to encourage or mandate solar orientation of subdivisions. Among these few cities were Port Arthur, Texas and Boulder, Colorado. For illustration purposes, Port Arthur’s solar orientation ordinance states that:

“Streets shall be designed so that at least eighty (80%) percent of the buildings in the subdivision can be oriented with their long axes parallel to nine (9°) degrees south of west with a possible variation to six (6°) degrees north of west or to twenty-five (25°) degrees south of west. – (Ordinance No. 79-89 Port Arthur, Texas 9.4.79, 2, 1979).”
Erley and Mosena, however, note that compliance with the ordinance was rewarded with a reduction in required street widths and reduced expenses for developers (471-474). While Port Arthur recommended a particular range of degrees within which subdivisions could be oriented to maximize solar gain, that range varies with climate and goals for passive solar orientation. Crandall’s recommendations on proper orientation for each type of climate are below in Table 2.

<table>
<thead>
<tr>
<th>Hot Humid Regions</th>
<th>Hot Arid Regions</th>
<th>Temperate Regions</th>
<th>Cool Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimize east and west facing walls.</td>
<td>Minimize east and west facing walls.</td>
<td>Maximize southerly wall exposure for winter warmth</td>
<td>Maximize southerly wall exposure for winter warmth</td>
</tr>
<tr>
<td>Five degrees south, southeast building orientation preferred.</td>
<td>Twenty-five degrees south, southeast building orientation preferred.</td>
<td>Seventeen degrees south, southeast building orientation preferred.</td>
<td>Twelve degrees south, southeast building orientation preferred.</td>
</tr>
<tr>
<td>Glazing on south facing walls preferred over east and west.</td>
<td>Optimize glazing on south facing wall and minimize glazing on north walls.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An innovative energy conservation neighborhood built in the 1970s in Davis, California, Village Homes, also incorporated passive solar design among its many energy conserving features. In cataloging the energy efficiency measures undertaken by Village Homes’ designers, Francis explains that “all streets run east-west and all lots are oriented north-south. The orientation helps the houses with passive solar designs and makes full use of the sun’s energy. [Also, t]he roads are all narrow, curving cul-de-sacs; they are less than 25 feet wide and generally are not bordered by sidewalks. Their narrow widths minimize the amount of pavement exposed to the sun in the long, hot summers” (33).
These policy examples at state, city, and development level indicate the relative ease with which passive solar orientation can be incorporated into current land planning policy. While cast shadows from adjacent buildings in urban infill sites remains a concern, a vast majority of development in a city takes place beyond infill areas, and many infill sites are unaffected by cast shadows. Therefore, Owens states, “there is little reason why the principles of passive solar and microclimatic design should not be applied in a substantial portion of new developments. In general they are not, however, because they often fall into a policy vacuum between planning and building regulations. There is scope here for a significant policy initiative to ensure that these simple cost-effective measures are considered at an early enough stage in the urban development process” (Owens (a), 84). Finally, while passive solar design remains among the easiest ways for planners to impact urban energy consumption, many other methods for achieving energy conservation and alternative energy supply complement and enhance the efficiency gains from passive solar design.

**Landscaping and the Urban Heat Island effect**

Landscaping plays an integral role in site planning for energy conservation through altering microclimate conditions to reduce heating from the sun or cooling from winds. When used in combination with passive solar design, landscaping can either enhance or detract from the energy efficiency and alternative energy supplies for any particular site. In particular, planting trees can be a useful site planning strategy in many different climates, serving to shade buildings from sun and channel wind for ventilation in hot climates and to shield buildings from wind in cold climates. Additionally, by changing the color of roofing materials to better reflect solar energy instead of absorbing it, planners can reduce the effects
of the urban heat island, and reduce the necessity for mechanical or electrical cooling during hot summer months.

The Center for Housing Innovation explains that the urban heat island is a pervasive effect in cities, because “where trees and other vegetation have been replaced by buildings and pavement, solar radiation is readily absorbed and stored. Building and pavement surfaces absorb and hold heat throughout the day. As cool evening air comes in over the city, the warm air is trapped, and air pollutants generated by cars and other city processes are also trapped and settle, causing temperatures to increase by as much as 3 – 10 degrees. In warm weather this in turn will increase the use of fossil fuels burned to cool buildings and vehicles” (Center for Housing Innovation, 49).

Implementing a landscaping strategy for energy conservation at the site level is a “no-regrets” scenario – landscaping is viewed as site-enhancing. Sewell and Foster, describing a meeting of Canadian planners on energy conservation strategies note that “it was agreed that the intelligent use of microclimate to reduce energy use was an effective way to conserve energy and that municipalities had nothing of significance to lose in promoting it. Little quantitative evidence was put forward, however, to illustrate the size of such potential energy savings” (Sewell and Foster, 28). This criticism may have been valid in the 1970s, but research into the specific energy reduction provided by landscaping has advanced significantly since that time. Quoting a report from the U.S. EPA in 1992 in a guide to site planning for energy reduction, the Center for Housing Innovation reports that:

“Trees moderate the urban heat island by shading, or blocking, the sun’s radiation. Heavy canopy trees can block up to 95% of incoming radiation. Shading buildings helps to reduce the need for summer cooling, while shading outdoor areas helps to keep air temperatures lower in urban areas. Three well-placed shade trees around a house can cut air conditioning energy needs by 10% to 50%. Conversely, well-placed
trees can also reduce wind speeds and thus heating needs in cold climates” (Center for Housing Innovation, 51).

Various site planners indicate the proper ways in which landscaping should be placed on the site to reduce energy consumption in buildings. Most describe two types of plantings are necessary depending on site conditions and local climate: windbreaks or windrows and shade trees. Wheeler suggests planting “windrows to shield buildings from cold winds or deciduous shade trees to reduce temperatures during the summer while allowing sunshine to enter south-facing windows in the winter” (223). In his text Site Planning and Site Design Handbook, Russ explains that 30 percent gains in summer energy efficiency are possible from properly located native tree species, which not only shade buildings, but provide evaporative cooling and reduce reflected light from other buildings (338). Trees’ absorbtion of solar energy occurs through evapo-transpiration, a process which consumes solar energy, releases water vapor, and reduces air temperature. In fact, “a single tree can transpire up to 100 gallons of water a day during the growing season. This has the same effect as running five average air conditioners for 20 hours” (Center for Housing Innovation, 51).

Additionally, “buildings can also be cooled using arbors and vines. Arbors are used throughout the world for cooling. Vines will reduce summer heat by absorbing much of the light. Deciduous vines lose leaves and allow winter heat gain” (Russ, 338).

Unlike passive solar orientation, tree preservation and planting ordinances are already incorporated into planning and subdivision ordinances of many cities due to water and air quality or aesthetic concerns. Ensuring that cities site planning and subdivision ordinances require planting trees in certain locations to maximize energy conservation may require tweaking of these ordinances. As Russ notes:
“Sunscreens are most effective when located on the western and southwestern sides of buildings to reduce heat from the summer setting sun. Deciduous trees on south sides of buildings will admit winter sun but block summer sun. Medium to large trees located 15 to 30 ft. from buildings are most effective. As a rule of thumb, the distance between the building and the tree should be about \( \frac{1}{4} \) to \( \frac{1}{3} \) the mature height of the tree. Smaller trees may be planted closer, but summer breezes they generate may be less than they would be farther away from the building” (Russ, 338).

In addition to strategically planting trees to shade buildings to reduce the ambient air temperature, roof colors should be light to reflect light back into the atmosphere rather than absorbing the energy and heating the air. Planners can alter the building code to help reduce energy conservation through altering the color of roofing materials for buildings. Though architects often choose to avoid lighter colored roofs because they show dirt, “what they are doing is creating a roof that gets ninety degrees hotter than the surrounding air, instead of the fifteen degrees of a white roof. This extra heat soaks into the house, forcing the air conditioner to work 20 percent longer and use a fifth more power. ... In Los Angeles, the combined effect of so many million dark roofs, as well as dark asphalt roads, forces the city to use up an extra 1,500 megawatts of power cooling itself – the equivalent of one-and-a-half power plants – or about 3 percent of California’s total summertime power load” (Roberts, 229). Wheeler suggests a punitive policy, where local government “charges for development ... that exacerbates urban heat island effects (through excessive paved surfaces and poor landscaping)” (Wheeler, 234). Through incorporating tree planting requirements, which vary by climate, in site planning and subdivision ordinances, enforcing current tree preservation ordinances, and encouraging additional plantings of vines or use of arbors to cool buildings or shield buildings from prevailing winds, from 10 to 50% of building heating and cooling energy consumption can be avoided. An additional reduction in energy consumption can be incorporated through altering the effects of roofing on aggravating the urban heat island...
effect. Incorporating landscaping ordinances and changes in allowable roof colors in the building code with passive solar orientation ordinances can provide reinforcement and synergies in reducing energy consumption at the site level, and additional green building guidelines.

**Green Building guidelines**

In addition to traditional planning activities like regulating orientation of buildings on a site and site landscaping for energy conservation, building design plays an important and related role in regulating the consumption of energy in cities. With the emergence of green building codes pioneered by private organizations such as the U.S. Green Building Council and progressive cities such as Austin, TX and Boulder, CO, planners now have the opportunity to encourage or require construction of buildings which consume dramatically less energy than previous building codes required. Because of the important synergies between site planning and building design, planners should help implement green building codes and standards to reduce energy consumption in cities.

While planning has traditionally been concerned with conserving energy from land use patterns, site design, and landscaping, green building codes and standards take into account many different types of energy consumption. Buildings consume energy in five distinct phases:

“The first is related to the manufacturing of materials, components, and systems, which is termed **embodied energy**. The second, which is associated with the energy consumed for the transportation of materials to the site, is known as **grey energy**. Third, **induced energy** applies to the energy expended in the construction itself. Fourth, the **operating energy**, the form of energy that has prompted most consideration, is the energy actually spent in the running of the building, as long as the building is occupied. Finally, a building also consumes energy in its final disposal or, eventually, in its recycling, which is the **disposal and recycling energy** phase. All things considered, the most energy-intensive phase is the operational one which corresponds to the running of the building throughout its life cycle – usually
estimated at 60 years or as long as the building stands and is occupied – and is therefore related primarily to the energy dispensed in the systems of acclimatization and lighting” (Presas, 38-39).

Through implementing green building codes, cities aim to reduce energy across all five phases of a building’s life. Builders achieve savings through a combination of efforts, though they are primarily focused on methods “to meet building heating and cooling needs in ways that minimize energy use. Vernacular architecture can provide many clues, though other green design techniques are useful as well.” Additionally, replacing electric lighting with daylighting and more efficient light bulbs plays an important role in reducing heating and lighting needs (Wheeler, 225-226). Ecological designer Sim van der Ryn provides an appropriate metaphor for relating buildings to the natural world, comparing green buildings to living organisms:

“If we begin to think of buildings themselves as organisms with functional relationships to their environment, new possibilities emerge. In designer Day Chahroudi’s vision, the building is a ‘one-celled organism whose environment contains all the necessary nutrients and also some hostile elements. ... Using the selective permeability of its roof or walls the building exhibits homeostasis, perhaps the most basic property of living things.’ The selective permeability is obtained by coating the inside of an ordinary window with a heat-reflective layer. The window lets in light but traps reradiated heat. This helps to allow a building, with proper solar orientation, to adapt itself to the local climate. In such a design, the harsh walls favored by industrial designers become softened to biological membranes... The building stays warmer in cold weather and cooler in warm weather” (van der Ryn and Cowan, 74-75).

In addition to energy conserving windows and daylighting, Riddell recommends “installing high-rating building insulation, energy-smart glazing, solar water heating; also installing chip-controlled micro-climate management systems within larger buildings, heat-exchange pumps, variable speed electric motors, and halogen light bulbs among a host of energy-conserving soft-pathway technologies” (Riddell, 102) to achieve green building goals.
Policy Implementation: With many technological and design options available for builders to utilize in designing buildings with energy conservation in mind, planners are well positioned to implement innovative green building codes, energy conservation standards, or other policies to reduce consumption of energy by urban buildings. Many states and several local governments have addressed energy efficiency in building codes, though as Beatley notes, American green buildings comprise “a haphazard, scattered set of buildings and projects (many very impressive), ... driven more by enlightened clients and specific designers than by strong public policy” (313). More than half of all states in the United States included “energy efficiency requirements into their building codes, resulting in large savings in energy use for home heating and cooling. California, for example, established Title 24 of its building code in the early 1980s to raise requirements for energy efficiency, and through this conservation initiative now saves the energy equivalent of the production of several large power plants. However, many other states, including Arizona, New Jersey, Texas, Illinois, and Michigan, have yet to adopt energy efficiency codes” (Wheeler, 128). Davis, California, however, implemented extensive changes requiring certain energy conserving features including insulated windows which “was initially opposed strongly by developers who considered that it would lead to expensive, aesthetically unpleasing housing, and that orientation requirements would mean lower densities and reduced profits. Their fears proved unfounded, since housing costs increased by only one or two percent and there was no change in appearance” (Owens (b), 87).

In addition, many older building codes consider energy efficiency in buildings in a piecemeal way – requiring efficient air conditioners and light fixtures without giving a thought to avoiding the need for air conditioning or electrical lighting in the first place.
Wheeler, while acknowledging the benefits of using building codes to spread sustainable design and building practices, feels that standards can become rigid, inflexible, and prevent innovation; “for example, straw bale construction was forbidden by building codes in most communities until these codes were amended in the 1990s. Firmly established standards may reduce creativity, in that design or development becomes a process of meeting established benchmarks rather than ‘pushing the envelope.’ Extensive formalized standards can also add cumbersome bureaucracy and paperwork if not developed carefully” (Wheeler, 94).

Newer, so-called “green building codes” promote an integrated method for considering energy consumption and efficiency in building construction through attempting to avoid energy consumption at all. These codes provide energy consumption information to building owners and lessees, and represent a way to avoid creating prescriptive building codes. Instead, “a building or development must simply meet certain overall criteria, such as keeping energy use below a certain level. ... The exact means are up to the developer or policy-maker, thus opening the door to creative new approaches” (Wheeler, 94). A prime example of this type of code, which has been adopted as an energy efficiency standard for many cities, is found in the U.S. Green Building Council’s LEED (Leadership in Energy and Environmental Design) energy efficiency standards for new construction, renovations, and draft standards for residences (Wheeler, 94). LEED is representative of a group of points-based, certified energy rating systems also adopted by cities such as Austin, Texas, Boulder, Colorado, and Denver, Colorado. LEED is structured to provide a combination of required energy conservation measures and additional energy conservation measures, which are certified through a variety of means, and used to label buildings according to a rating system based on how energy efficient a building is.
Green building’s roots in local government actions in the United States can be traced to the City of Austin, Texas, which owns a municipal utility and sought ways to avoid building a new 500 megawatt coal-fired power plant to meet growing electricity consumption. Originally begun in the 1980s as a new way of labeling energy efficient homes, in 1991 the program was expanded as the “city of Austin seeks to promote more sustainable and ecological building and construction through a combination of builder and consumer education, and especially through a certification process that awards green builder “stars” to homes and buildings that meet certain green criteria. Participating builders must attend training in green building (both an initial basic program and ongoing seminars)” (Beatley, 319). In addition, the City of Austin’s green building guidelines “provide developers and architects with details about how these criteria can be met, and the city offers a variety of technical-support services and cash incentives for green buildings” (Wheeler, 228-229). Boulder, Colorado has gone a step further than Austin in mandating that buildings be constructed under their “greenpoints” system. All construction must have a certain number of green building points, though the city does not prescribe the measures needed to reach the green building goal; instead “builders are given a choice of design features and technologies from which they must amass a minimum number of greenpoints, depending upon the square footage of the structure. ... Additional construction costs resulting from the greenpoints features are estimated in the range of 1 to 3 percent (seen as modest) and are often paid back in other long-term savings (such as reduced energy consumption)” (Beatley, 320). Similar programs have spread rapidly across the United States, and “as of 2001, 16 other cities nationwide had developed similar programs. Denver’s Built Green program, for
example, certified 3000 homes in 1999. Although such programs currently affect only a small percentage of the building stock, their influence is growing” (Wheeler, 228-229).

Though many of these programs are voluntary, Beatley remains optimistic about the growth of green building codes - “programs and initiatives that represent important policy directions but that will require significant expansion in the future. Not surprisingly, many of the U.S. approaches entail a heavy free-market orientation: an emphasis on creating incentives and a strategy of ecolabeling homes to encourage buyers to be more conscious of the choices they make concerning, in particular, the energy-consumption attributes of new homes” (Beatley, 316). Through consciously incorporating energy consumption as an attribute to be controlled by local building codes, either through an alternative building code which allows for innovative design practices, a prescriptive building code which mandates energy conservation through specific design strategies, or one of the newer “green building codes,” planners and local policy makers can quickly decrease the amount of energy new construction consumes with dividends paid over the operating lifetime of buildings.

Active solar: solar photovoltaics & solar water heaters

Many traditional planning strategies focus on energy conservation; few have focused on increasing renewable energy supplies which can replace fossil fuel energy. The United States has multiple renewable energy resources, distributed over the entire area of the country:

“Communities on open plains, mountainsides, or coastlines have wind resources that can be used either for pumping purposes or for making electricity. Southern communities are bathed in solar energy usable for heating, cooling, and electrical generation using both photovoltaics and solar-thermal-electric power technology. Western communities can tap geothermal resources. Landlocked communities can harness the power of rivers through small-scale hydro-electric dams. Rural communities have a surplus of agricultural, forestry, and animal wastes that can be used as or converted into combustible fuels. ... Technological innovations of recent
years are steadily improving the ability of communities endowed with renewable energy resources to tap them economically” (Beatley, 284-285).

Several forms of these alternative energy sources are available for residential and commercial use, including solar hot water heaters, solar photovoltaics, and wind turbines. Two types of active solar options are available: solar photovoltaics and solar hot water systems. Pearson defines an active solar system as one which “relies more on mechanical components such as solar panels, which absorb the sun’s heat and store it in water tanks, rock beds or similar. Pipes and ducts distribute the heat with the aid of fans, pumps, and valves” (Pearson, 86). Photovoltaic solar panels are perhaps the most well known type of active solar. Available for placement on rooftops or in concentrated solar farms, “photovoltaic (PV) cells convert sunlight into electricity, reducing the total amount of energy used from exterior sources” (Pinderhughes, 106). While at present more expensive than traditional fossil-fueled electricity, “power from photovoltaic (solar) cells has become steadily cheaper and may soon compete head-to-head with fossil-fueled power plants. ... Improvements in technology have lowered both the energy and economic costs of manufacture, a trend that continues. [Also, f]lexible panels may someday be used for roofing” (Crawford, 113-114). By creating electricity from the sun, building owners can avoid using electricity from other sources, avoiding emissions from fossil fuels burned to create electricity.

An additional, though mostly overlooked, active solar resource involves using solar energy to heat water as opposed to traditional natural gas or electric hot water heaters. This technology has been commercially available since the 1970s, and many communities heavily promote or require their use, as they can provide up to 100% of hot water needs in summer months and a significant percentage during winter months. Pinderhughes notes that these “advanced systems for solar thermal water heating are relatively cheap and simple. About 1.5
million homes and 250 thousand commercial and industrial buildings in the United States use solar thermal hot water heaters; homes using solar thermal water heaters in the United States recovered the cost of the new systems in five to ten years from energy savings” (121). As natural gas prices have risen precipitously over the last 5 years, solar hot water heaters increasingly make financial as well as environmental sense. “In Southeast Asia, hot water from rooftop collectors is already cheaper than from gas-fired boilers. As external costs such as global warming are added to the equation, the balance will increasingly favor such installations” (Crawford, 115).

While large wind farms with power production capabilities equal to large power plants increasingly play a large role in electricity production in the United States, wind turbines are also increasingly available for residential and commercial projects. Green and Sagrillo note that “at least ten companies are currently active in this market with small wind turbines, up to 100 kW. The market is driven in no small part by emerging state incentive programs for small, distributed renewable energy systems” (1).

**Renewable Energy Policies:** In many cases, however, planning controls do not explicitly allow for installation of alternative energy generation such as photovoltaic solar panels, solar hot water heaters, or any type of wind turbine, and in some cases explicitly ban these important energy generators. When prices for alternative energy sources placed solar and wind installations well out of the price range of normal family homes, zoning played little role in restricting construction. Now that many of these technologies have matured, and with the help of state and federal tax credits become more affordable, zoning restrictions are emerging as a significant problem for many local residents and businesses interested in reducing their energy consumption, especially since “generating electricity on-site through
solar or wind technology is often a possibility, and in many locations such current can be fed back into the grid when not used, literally running the meter backwards” (Wheeler, 222-223). While solar access presents a difficult challenge to existing zoning laws, many localities have solar access laws in place. On the other hand, wind turbine construction is typically not allowed because “local zoning authorities and neighbors of prospective distributed wind turbine owners usually do not understand the acoustic, visual, safety, and other impacts of distributed turbines—they tend to fear the worst and act accordingly” (Green and Sagrillo, 1). Wind turbine owners must typically go through the permitting process to obtain either a zoning variance or a conditional-use permit, though as Green and Sagrillo remark, “each of these options will likely require a public hearing and always require a specific and unique ruling by the zoning authority. All too often, the resulting process is slow, time-consuming, contentious, and costly. These means of zoning relief clearly are neither long-term nor broad solutions to the distributed wind zoning barrier” (5).

Local planners must consider how best to balance controlling any adverse effects of alternative energy technologies such as solar panels, solar hot water heaters, and small-scale wind turbines while allowing these technologies to increase the environmental sustainability of their communities. Model ordinances which balance the benefits and drawbacks of these alternative energy sources have been drafted by the American Wind Energy Association and the American Solar Energy Society, and their rapid adoption by local planners would ensure that cities across the United States could replace fossil fuel energy with local, renewable energy sources without undue effects on neighbors.
**Dwelling type and density**

Though planners often encourage population density for provision of efficient urban services, building densely provides significant energy saving over more sprawling development patterns by virtue of reducing total surface area of buildings exposed to ambient air. Walker and Rees state that dwelling type helps to determine energy consumption because of the proportion of walls and floors which are shared with other dwellings. The more surface area exposed to the atmosphere for transferring heat, the more energy must be consumed by a building to maintain a temperature. By attaching houses, and increasing building density, per-capita energy consumption for buildings decreased (Walker and Rees, 101). As Moughtin and Shirley point out, “a building which has the lowest ratio for the area of the envelope to the usable floor area, not only costs less to build for any given building volume (assuming the same materials are used in the construction), but also uses less energy to construct and is more efficient in terms of energy use during its working lifetime” (Moughtin and Shirley, 38-39). Crawford reveals that energy savings from attaching houses can be significant:

“When buildings touch other buildings on two sides, they use far less energy for heating and cooling. The common walls are at roughly the same temperature as the building interiors and so impose little heating or cooling load. Similarly, multistory buildings use less energy than single-story buildings because of the reduction in roof area per unit floor area. The combined savings can exceed 50%... For example, consider a 144 square meter single-story detached house with a flat roof. The house is 18 meters wide and 8 meters deep (typical values for smaller North American suburban houses). Assuming the walls are 3 meters high, the building has 156 square meters of exterior wall and 144 square meters of roof, for a total exposed area of 300 square meters. If the same floor area is provided in a building 4 meters wide and 4 stories high, then the building is 9 meters deep. If this building adjoins its neighbors on the two long sides, then it has only 44% of the exposed surface area of its single-family detached cousin” (Crawford, 119).
Despite the effect that such changes in building density may have on energy consumption, planners must account for other factors which may influence energy use equally to tease out which areas planners can influence. Owens notes that “empirical work both in the USA and in the United Kingdom has demonstrated significant correlations between domestic energy consumption and the percentage of various types of dwellings in any given area. The problem with such studies is that although they may indicate that energy demand is related to spatial structure, it is not usually shown how much of the variation may be attributed to built form alone as opposed to other variables such as the size of the dwelling and the income of its occupants” (Owens (b), 43). Similarly, should studies conclude that attached housing or other changes in residential density provide significant energy savings, White cautions that “the housing market will be slow to respond to the issues of environmental change, even when the benefits of improved practice can clearly be shown” (95).

With these caveats, built form and residential densities play an important role in reducing urban energy consumption. Owens notes that “when all (energy) factors are considered, moderate to high densities emerge favorably, since these encourage efficiency in a number of different ways, but need not preclude the use of renewable energy sources” (Owens (b), 59). Planners would be wise to consider residential density in combination with other technologies and strategies which reduce the energy consumption of buildings in general, taking into account that “building form affects energy consumption with multi-unit structures, especially low-rise and small high-rise appearing to be optimal. More important, however, is the level of thermal efficiency of the structure” (Sewell and Foster, 72). Additionally, Walker and Rees note that “higher densities also facilitate the use of more
efficient energy technologies, such as district energy systems which are used extensively in Scandinavia and northern Europe. ... In Britain, a threshold of 44 units per hectare [17.8 units per acre] was considered to be the minimum density required to introduce district energy systems” (Walker and Rees, 101).

Through a combination of site planning measures, including passive solar design, landscaping for energy conservation, implementing green building guidelines, allowing active solar collectors including solar photovoltaics and solar water heaters, and building at medium to high densities, planners can dramatically reduce energy consumption in cities. These measures, though not all traditionally considered to be within the realm of planning responsibilities, provide planners with readily achievable policy measures to curb energy consumption in new construction in cities. Such policies, however, do not address many other measures which local officials and planners can undertake to reduce urban energy consumption.

OTHER IMPLEMENTABLE MEASURES

Energy conservation through site planning, building design, and increasing residential densities provides planners with many opportunities for reducing energy consumption through relatively easy changes to include energy consumption as a consideration in land planning. Additionally, through changing zoning regulations to allow alternative energy technologies to replace conventional sources of electricity and natural gas, planners can significantly aid the spread of decentralized, renewable energy. Local governments, however, can do more to implement energy conservation at the site level, including leading energy conservation by example, concentrating on weatherizing existing buildings, and exploring the
use of combined heat and power systems to dramatically increase the energy performance of existing buildings and government properties.

_Governments leading the way_

Implementing energy conservation measures through site and neighborhood planning has often begun with governments conserving energy in their own operations, providing subsidies for alternative energy installations, or beginning weatherization programs for poorer residents. In Europe, “cities tend to use much less energy and thus produce less carbon dioxide than American cities. Similarly, they generally place much greater importance on promoting energy conservation and renewable energy sources” (Beatley, 258). Cities can undertake a variety of programs, ranging from education and energy audits to conservation efforts for government buildings to many of the suggestions for implementing site planning changes noted above. During a short period in the late 1970s, Seattle implemented a broad range of programs in response to the energy crises of the time. “The major emphasis in all program development has been on ‘imaginative conservation’ rather than ‘belt-tightening measures.’ None of the programs listed below [see Table 3 below] are of the take-a-quick-shower or leave-your-thermostat-at-65° variety. They are such things as building code changes [that] do not lower the standard of living, but do lower the costs and consumption of electrical energy. The programs are divided into four categories (Education/Consumer Information; Revision of Codes and Standards; Research and Development; and In-House Projects)” (United States, 162). An innovative example included Operation Fire/Power, where energy audits were conducted by trained fire fighters at the same time as fire safety inspections.
Cities throughout the world have taken charge in promoting energy conservation and alternative energy supply. Since the mid 1960s, “Newcastle City Council has promoted energy efficiency and the production of cleaner energy. In 1968, the Council was one of the first in the UK to invest in energy conservation, and since this time various experiments with energy efficiency, waste to energy, CHP and district heating schemes have been launched in order to tackle social problems caused by poor housing conditions and to reduce energy costs for the Council” (Bulkely and Betsill, 70). Not only were social problems addressed, but “the drivers [for energy efficiency] in the early stage were financial ... there was a lot of money saved, and a lot of money was able to be reinvested and the savings got bigger, and bigger, and bigger as this rolling programme went on” (Bulkely and Betsill, 71).

Other programs such as direct subsidies for promoting alternative energy supply have arisen in Europe and the United States. “Cities such as Freiburg, Berlin, and Vienna are actively promoting solar energy through the provision of subsidies” (Beatley, 271). Austin, Texas also provides a $4 per watt subsidy for new photovoltaic solar energy projects (Austin

<table>
<thead>
<tr>
<th>Education/Consumer Information</th>
<th>Revision of Codes and Standards</th>
<th>Research and Development</th>
<th>In-House Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weatherization/insulation retrofit</td>
<td>Building code revision</td>
<td>Electrical energy performance standards</td>
<td>In-house conservation</td>
</tr>
<tr>
<td>Energy efficient home certification</td>
<td>Lease-sale-rent energy use disclosure</td>
<td>Solar/wind utilization</td>
<td>Street light energy use reduction</td>
</tr>
<tr>
<td>Education/outreach (Thermographic flyover) (Mobile exhibits, literature)</td>
<td></td>
<td>Tracking of legislation/codes/standards/grants</td>
<td></td>
</tr>
<tr>
<td>Operation Fire/Power</td>
<td></td>
<td>Research &amp; development</td>
<td></td>
</tr>
<tr>
<td>Advertising/promotion</td>
<td></td>
<td>Rate review</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 3: Overview of Seattle’s 1975-1977 Energy Conservation Programs (United States, 162-164)
Energy, 1). Many cities across the nation, however, are not responsible for energy supply or must compete with other levels of government for oversight and regulation of energy issues in cities. Bulkely and Betsill state that:

“the ability of any given local authority to address climate change is conditioned by the broader political and economic context in which it operates. ... Swedish cities have greater scope for action than their British counterparts in large part because they have municipally owned utilities and greater financial independence. While the City of Toronto owns its electric utility, its ability to influence greenhouse gas emissions in the energy sector is limited by the fact that the provincial government has the authority to regulate utilities” (Bulkely and Betsill, 50).

Regardless of utility ownership, local governments can lead a push for energy efficiency and promote alternative energy supplies. Cities such as Seattle and Austin have municipal utilities which serve their residents with energy, though other progressive cities such as Boulder do not. By addressing energy efficiency issues through methods other than planning, local governments can successfully reduce energy consumption and promote alternative energy supply.

**Weatherizing and insulating existing buildings**

A majority of the suggestions for site level energy conservation have been applicable almost entirely to new construction. Cities, however, must recognize that a large quantity of buildings that exist today have lifespans of 20 years or more, during which time they will be consuming energy, often much less efficiently than newly constructed buildings, and “given the low turnover of buildings, the largest potential for improving energy performance, in the short-term, is in the existing building stock” (Mega, 55) Therefore, undertaking a weatherizing and insulation program for existing homes and buildings can lead to relatively inexpensive gains in energy efficiency for the city as a whole.
Residential buildings can often benefit from upgrades to building materials, incorporating many of the features mentioned throughout this paper. Pearson gives an example of “an average-sized, older-style house [which] uses 20,000 to 30,000 kWh of energy each year. Of the total cost of energy, about 30 per cent (depending on climate and the level of insulation) goes on space heating, 15 percent on hot water, and 40 per cent on cooking, lighting, and appliances. The remaining 15 per cent goes on maintenance and standing charges. By improving insulation and draughtproofing and by using better controls, it is possible to save at least half the money now spent on heating and hot water” (74). In addition to landscaping and adding alternative energy systems to a house, new building materials also provide efficient alternatives. “Highly energy-efficient windows, wall insulation, appliances, water fixtures, and lighting are now widely available. Using double-glazed or triple-glazed windows (with two or three layers of glass) is one of the most effective ways to insulate a building as well as to reduce noise from traffic or neighbors outside. The introduction of compact fluorescent lightbulbs in the 1980s and 1990s has represented one of the biggest energy savings breakthroughs of all, since these bulbs typically use one-fifth the electricity of a conventional incandescent bulb” (Wheeler, 226).

In addition to energy gains, planning a weatherization campaign can increase equitable access to energy services of heating. Grier notes that “far fewer low-income than high-income houses were equipped with insulation (24 percent) and storm windows (40 percent) in 1975. Most low-income families cannot afford to install these items without assistance even if they want to do so and the basic quality of the dwelling warrants it” (Grier, 12). Many U.S. cities have taken action to reduce costs for low-income residents, and “city governments in cold climates have been particularly active in helping low-income residents
weatherize their homes, since these residents frequently live in the most poorly insulated dwellings and may not be able to afford to do so otherwise. Such programs can be seen as promoting equity (improving quality of life and saving money for the most needy). However, much more remains to be done on this front” (Wheeler, 171).

Though optimistically predicting the replacement schedule for alternative energy supplies at 20 years, Rosenfeld and Ward estimate that “energy efficient retrofits (improvements in existing buildings) can affordably reduce demand in U.S. buildings by as much as 50% ... [and] can bridge this time gap” to a fully renewable energy supply. (Rosenfeld and Ward, 223-224). Weatherization will not act as a gap measure, as Rosenfeld and Ward claim, but is instead a significant part of meeting a renewable energy future. Only through reducing energy consumption and increasing alternative energy supply can urban energy systems become sustainable.

**District heating and combined heat and power**

Increasing energy efficiency of new buildings and weatherizing old buildings provides a first step in dramatically lowering energy consumption, and replacing or supplementing energy supply with alternative energy sources can reduce fossil fuel energy consumption at the city level. Given sufficient urban densities, however, basic fossil-fuel fired electrical and heating services for buildings can be provided much more efficiently using combined heat and power (CHP) or district heating (DH) than normal electric services and individual heating systems for each building through a process known as cogeneration. Cogeneration takes place when:

“waste heat from a turbogenerator is used to provide process heat, air conditioning, and space heating. The net efficiency of cogeneration systems is much higher than that of stand-alone generating plants, which discharge more than half the total energy consumed directly into the environment in the form of low-grade thermal energy.
Small cogeneration plants are a proven technology, providing a city district or even an individual housing project with both electricity and space heating. Cogeneration offers the further benefit of greatly reduced electrical transmission losses because the power is consumed near where it is generated. These plants can be fueled by practically anything that burns, including trash and biomass” (Crawford, 116).

These combined heat and power plants have been in widespread use in Europe for several decades as noted earlier, and despite past problems, “district-heating projects ... are likely to become more generally applicable and widespread. Latest developments use local, small-scale generators in large offices, hotels, and leisure facilities” (Pearson, 94).

Large amounts of heat are wasted in traditional electrical generation, as demonstrated in Figure 2, below. White notes that “the waste heat from Ontario Hydro generating stations at Pickering and Lakeview alone could replace all other energy consumed for heating of interior building space in Metropolitan Toronto which cost approximately $1.4 billion in 1988” (186). Gains in energy efficiency from combined heat and power plants present a tremendous opportunity to alter the amount of energy consumed for electricity and heating. Owens notes that “the overall efficiency of primary energy use with CHP [combined heat & power] can be as high as 80-90%, representing considerable improvement on the separate production of electricity and heat. Hot water is distributed to buildings through a system of pipes forming a district heating network. ... The potential for
the introduction of CHP/DH depends (among other considerations) on the density of development and on the degree of mixing of different land uses” (Owens (b), 52). Densities for this type of power plant must be high, although smaller scale plants can provide heat and power to hospitals or government facilities. Beatley believes that with some creativity, residential districts could be easily connected to these systems (285-286). Indeed, Austin, Texas’s redevelopment of an inner city airport location, a combined heat and power plant is expected to service both a children’s hospital and several blocks of multi-family residences with air conditioning and electricity (Center for Maximum Potential Building Systems, 53).

While many consider combined heat and power districts on the scale of European cities to be out of reach for American cities, planners should encourage their use in appropriate situations, and with attempts to increase density in urban areas ongoing, opportunities for their use are expanding.

CONCLUSIONS

Through planning mechanisms and innovative local government programs such as subdivision regulations; zoning regulations that allow increased density, protect solar access, and plan for renewable energy supplies; green building codes, weatherizing programs, and exploring combined heat and power districts, cities have the ability to dramatically reduce energy consumption from the built environment. As Wheeler notes, site planning provides important inroads into reducing energy consumption and increasing alternative energy supplies, primarily because “planners have a great deal of control over the character and form of neighborhoods, and can potentially help bring about more sustainable types of neighborhood design. Legal and institutional mechanisms, including zoning ordinances,
subdivision controls, design review standards, and the processes of development approval, are relatively well developed for action on this scale” (Wheeler, 183). Cities cannot, however, pursue these programs in isolation; the more measures that cities implement to reduce energy consumption and increase alternative energy supplies, the more synergies for energy conservation can be captured.

Planners also cannot assume that simply increasing residential densities or platting subdivisions with smaller lots will necessarily solve energy problems. Despite a growing history of employing “smart growth” and “new urbanist” ideas in order to bolster true sustainable planning, planners must consider site orientation, tree preservation and landscaping, and reducing the energy use of individual buildings to substantially impact urban energy consumption. Bulkely and Betsill remark that there is often little consideration given to the relationship between land use planning and energy consumption, and that by making assumptions about the energy conserving nature of physical layouts for cities can be misleading without acknowledging that “energy use is dependent on both the form of urban development, that is, its location and density, as well as its design, [and] planning can be a means to promote more environmentally benign forms of energy supply and use. However, it is also important to note that the new urbanism says little about whether new buildings should integrate energy efficiency technology, how they might be placed to take advantage of passive solar energy and/or how planning might be linked to sources of electricity” (149).

The scale and scope of reducing energy consumption in cities presents numerous problems for planners. However, planners are in a particularly strong and well-placed position of mediating changes in urban development at the site level. Riddell notes that because large majorities of population in the United States and Canada are “urban, the
accumulation of urban lifestyle energy systems, when totaled, is impressive ... Adjustments in these ways reduces fossil-fuel and hydro energy consumption at no loss to overall standards of living or human comfort, and largely awaits individual realization and personal action, coupled to official endorsement and inducement, which has not been forthcoming from energy suppliers” (Riddell, 102). By explicitly acknowledging that conservation of energy and increasing access to alternative forms of energy, planners can incorporate measures of environmental sustainability into planning procedures, regulations, and programs, and create substantially more sustainable cities in the process.
WORKS CITED


