Wisconsin Land Use Megatrends:

Energy

Map 1: Wisconsin Energy Infrastructure[1]
This map displays energy generation and transmission facilities within Wisconsin. The vast majority of energy used within the state is derived from petroleum, natural gas, coal and nuclear imports, which results in a loss of nearly $15 billion annually from the state's economy. Resources produced within Wisconsin include wood, plant and animal-based biomass, solar, wind, and water.

Introduction

The production and distribution of energy in Wisconsin has distinct consequences for landscapes and land use. Whether the discussion is on non-renewable forms of energy, such as oil and coal, or on renewable forms, such as solar and wind, policy makers often focus their attention on broad economic, environmental, and financial considerations, but rarely on land resources. Many communities and citizen groups find it challenging to think about the range of spatial considerations associated with energy production and distribution. This challenge will grow along with Wisconsin's fossil fuel dilemmas and our state's efforts to develop renewable energy alternatives.

This publication is intended for local government officials and others interested in investigating the connections between energy and land use. Throughout these pages, we explore land use trends related to renewable and non-renewable energy. We present a map scenario illustrating how Wisconsin might achieve its goal of producing 25% of its energy from renewable sources by 2025. We wrap up by looking at building, transportation and community design approaches to reduce energy use.

Energy Trends

From 1970 to 2005, overall energy consumption in Wisconsin increased by 55%, more than double the rate of population growth (see Figure 1). The consumption of all types of fuel increased during this time period, with the largest increases occurring in coal, nuclear, and electric imports.[2] Per capita energy use in 2005 was close to the national median, as well as the median for states in the Midwest.[3] The states with the lowest per capita energy use all have higher energy prices than Wisconsin.[3]

Energy Consumption by Sector

Figure 2 shows that in 2005 four economic sectors each consumed roughly a quarter of the total energy used in Wisconsin: industrial, transportation, residential, and commercial. While all sectors consumed increasing amounts of energy since 1970, the largest increases have been in the commercial (139%) and transportation sectors (61%).[2]

Figure 1: Wisconsin Energy Production and Consumption

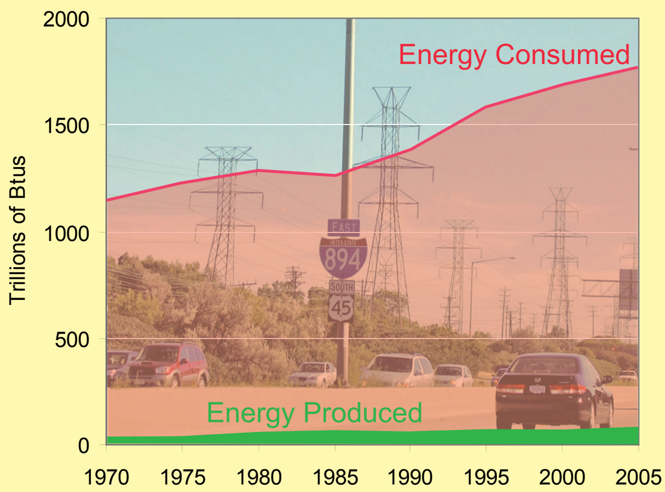


Figure 2: Wisconsin Energy Use by Economic Sector, 2005

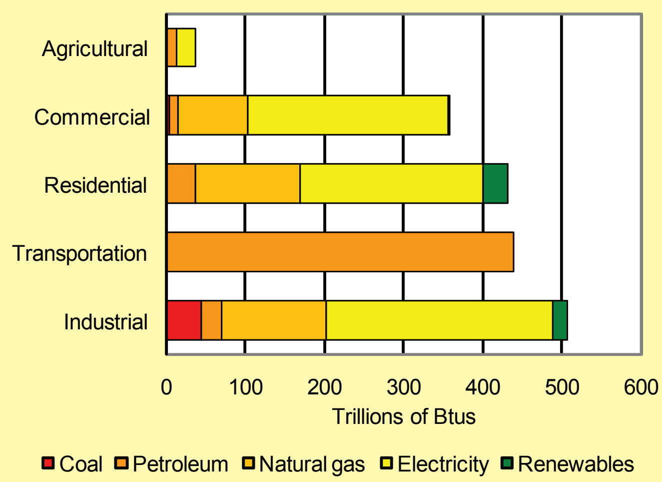


Photo: Wisconsin Public Service Corporation

Photo: US Coal Exchange

Non-renewable Energy

As shown in Figure 3, coal, petroleum and natural gas comprise over 80% of Wisconsin's energy consumption. While our state has many natural resources, virtually all of the energy we use is imported: coal from western states and the Appalachia region; oil from the Middle East and elsewhere; and natural gas from other states.[2] Approximately two-thirds of Wisconsin's energy expenditures leave the state's economy, a drain of $14.8 billion per year, or over $6,600 per household.[2,4] Trends suggest that importing fossil fuels may become more expensive.

Renewable Energy

Renewable energy comprises a very small portion of total energy at about 5% of total energy use in Wisconsin. As shown in Figure 3, wood dominates renewable energy use in Wisconsin (59%), followed by corn ethanol (13%) and hydroelectric power (9%).[2] Renewable energy use in Wisconsin has approximately doubled since 1970, yet still stands at less than 5% of total energy use.[2,5]

Energy Efficiency

The cheapest, cleanest and most reliable source of energy is the energy we avoid using. The energy we save through more efficient cars, refrigerators or furnaces occurs automatically while saving us money. Energy efficiency is often referred to as the "first fuel" in the effort to develop clean and secure energy resources. It does not infringe on other land uses and reduces the health and environmental impacts of our energy system.[6]

Energy efficiency has played a critical role in the U.S. energy supply in recent decades. Compared to a 1973 baseline, America now saves more energy than it produces from any single source, including oil. Efficiency improvements stabilize energy prices by reducing demand and the associated needs for new power plants and transmission lines, while also delivering the same services we value—whether hot showers or cold drinks—at a lower cost.[7]

The potential for additional energy savings is vast: U.S. energy use per dollar of GNP is nearly double that of other industrial countries. More than two-thirds of the fossil fuels consumed are lost as waste heat—in power plants and motor vehicles.[7] Combined heat and power generation, which significantly reduces wasteful heat loss, accounted for about 10% of Wisconsin's power generation capacity in 2006.[8]

Land use approaches to reduce energy use are discussed on pages 8-11 of this publication.

Figure 3: Wisconsin Energy Use by Type of Fuel, 2005

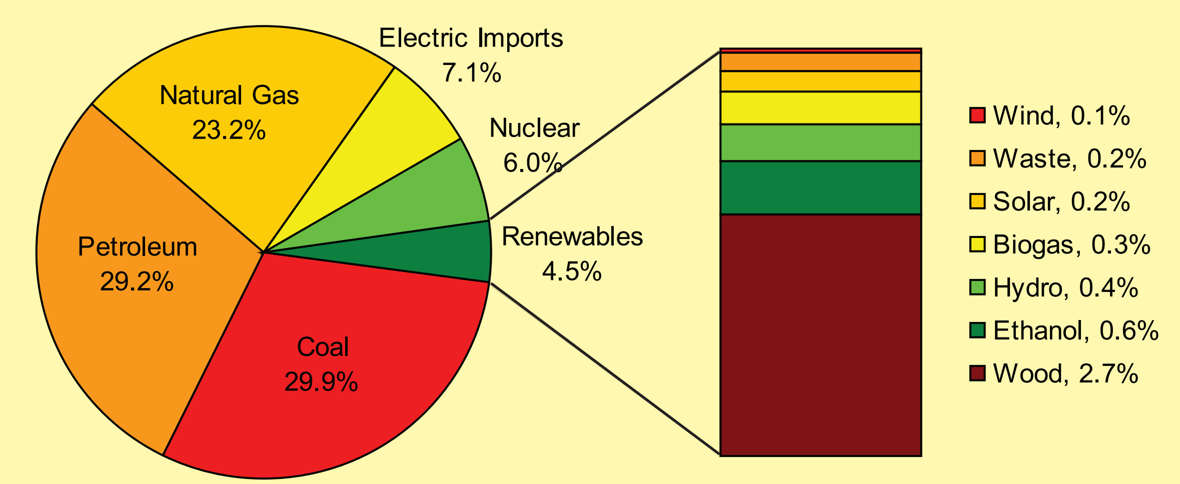


Photo: Wisconsin Distributed Resources Collaborative, Inc

Photo: Community Wind Energy LLC of Door County

Land Use Impacts of Conventional Energy

The infrastructure for producing and delivering energy in Wisconsin has numerous land use impacts. The locations of power plants and pipeline terminals are relatively fixed with few new sites being proposed relative to existing operations. Establishing new locations for major energy facilities is not an easy task as there are many regulatory procedures and associated reviews.

Recently, utilities have favored expanding operations at current facilities. The addition of a 500 megawatt coal fired power plant in Weston is an example of this trend. The new plant joins three smaller coal plants and two natural gas peaking plants at the same 345 acre site in central Wisconsin. Concentrating facilities in this manner reduces the amount of Wisconsin's landscape affected by power infrastructure but also intensifies the impact on the immediate surroundings.

Energy transmission infrastructure has a more extensive land use impact in Wisconsin than power generation facilities. Electricity transmission and distribution lines crisscross the entire state, and only the most remote locations are truly "off the grid". Gas and oil lines are less widely distributed but add still more land to the portion of the state that must be carefully managed to ensure that vegetation does not interfere with energy infrastructure.

Figure 4: Wisconsin law requires removal of trees, vegetation and other natural hazards that can interfere with electric transmission lines.

Photo: American Transmission Company

Vegetation management within energy transmission easements creates a network of lands that are perpetually kept in an "early successional" stage – dominated by grasses, shrubs, and young trees (see Figure 4). This poses little problem in the state's agricultural regions. In forested areas, however, the presence of an energy transmission line often results in some degree of landscape fragmentation (see Figure 5). Fragmentation refers to the slicing and shrinking of large pieces of habitat. Fragmentation of forests reduces habitat needed by forest dependent species such as American marten and forest warblers, but may open the way for disturbance dependent species such as the endangered Karner blue butterfly. Utility easements and maintenance can also introduce invasive, non-native species such as glossy buckthorn or garlic mustard.

Figure 5: The brown shaded areas illustrate the fragmentation of a stand of forest in Sawyer County by petroleum and electricity corridors.

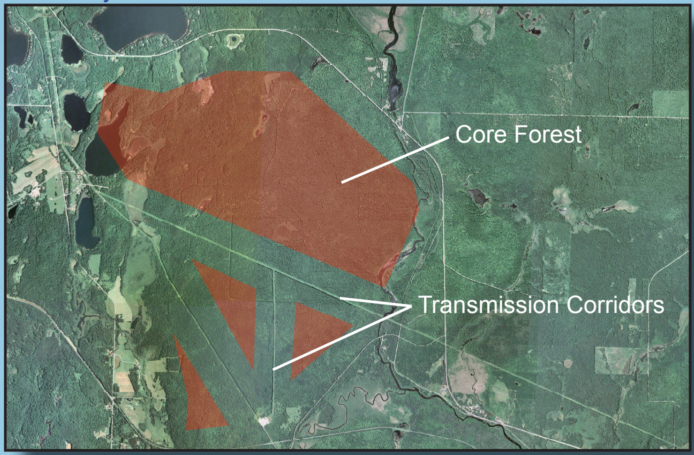


Photo: National Agriculture Imagery Program

Growing energy use in Wisconsin and the Midwest has fueled the demand for additional transmission facilities. In some cases, the transmission system can be upgraded in place to allow for more energy along an existing route. Such a strategy is not always feasible either because the existing lines are already at capacity or because the energy is coming from a new source. The addition of many new wind-powered turbines, for example, is being accompanied by miles of new transmission line.

Ideally, transmission systems would co-locate with transportation and other transmission systems, but this too is a challenge, as pipelines, highways, and powerlines all have somewhat unique engineering requirements (see Figure 6).

Figure 6: Petroleum and electricity lines coincide with this road in Washburn County. Different siting considerations preclude them from using the same corridor.

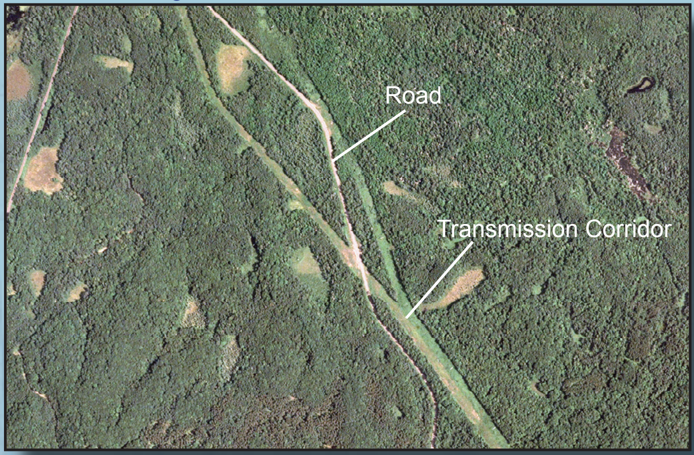


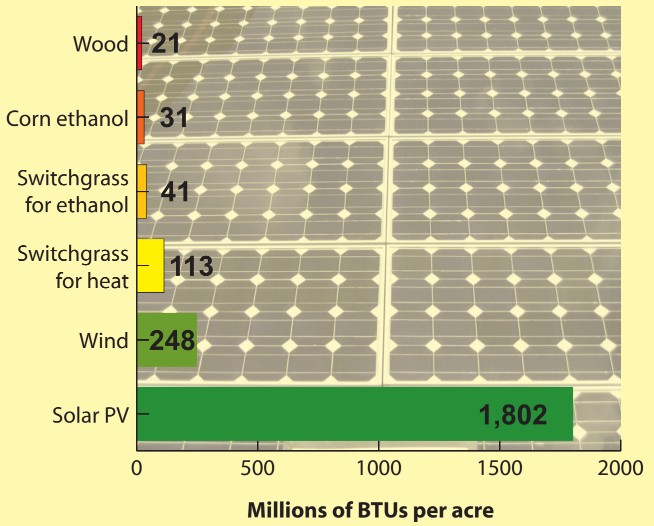
Photo: National Agriculture Imagery Program

Land Use Impacts of Renewable Energy

Energy Productivity per Acre

One way to think about energy production is the amount of land needed to produce various forms of energy. Figure 7 shows the productivity in millions of Btus per acre for various forms of renewable energy. Probably a surprise to most people is the high productivity per acre of solar energy (photovoltaic) as opposed to other forms.

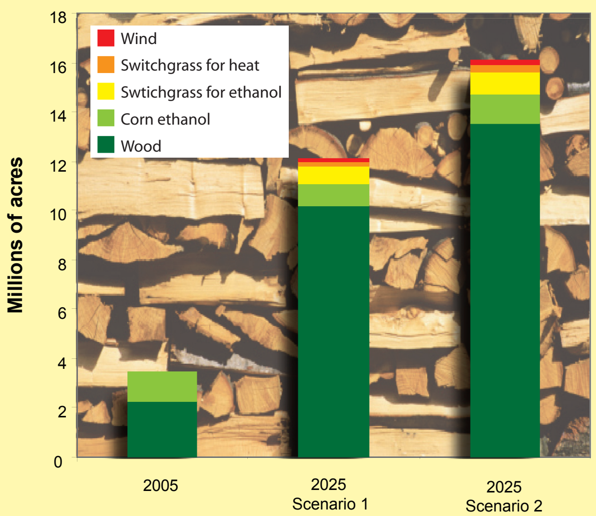
Figure 7: Wisconsin Renewable Energy Production (per acre)



Renewable Land Use Scenario

Figure 8 shows the amount of land that was used in 2005 for renewable energy production compared to two future growth scenarios. One scenario is based on a goal developed by the State of Wisconsin, Office of Energy Independence (OEI) to obtain 25% of the state's electrical energy and transportation fuels from renewable sources by 2025. One of the key assumptions in OEI's scenario is a significant reduction in current energy consumption through energy efficiency. The second assumes the same energy needs but does not include savings due to energy efficiency. There are two general approaches to achieving the 25 x 25 goal: reduce or at least stabilize energy consumption, and increase the amount of renewable energy produced.

Figure 8: Land Requirements for Renewable Energy Production



Scenario one shows the amount of land required to achieve the state's goal by increasing renewable energy production and implementing significant energy efficiency measures. Under this scenario, the state will need to decrease total energy consumption by 0.4% or 7.8 trillion Btus per year. Scenario two shows the amount of land required to achieve the goal if the state increases renewable production but continues to consume energy at its current rate of growth – presently at 2% or 18.4 trillion Btus per year. Under these two scenarios, Wisconsin's total energy consumption – which stood at 1,776 trillion Btus in 2005 – is projected to decrease to 1,620 trillion Btus (under scenario one), and increase to 2,144 trillion Btus (under scenario two).

Wood needs in 2005 accounted for 2.3 million acres of sustainably harvested forest land per year. By 2025, Wisconsin may need 10.2 million acres of sustainably harvested forest land per year under scenario one or 13.5 million acres under scenario two to meet its energy needs. These scenarios assume a sustainable yield, meaning not all the trees are harvested. Wisconsin currently has 16 million acres of forests.

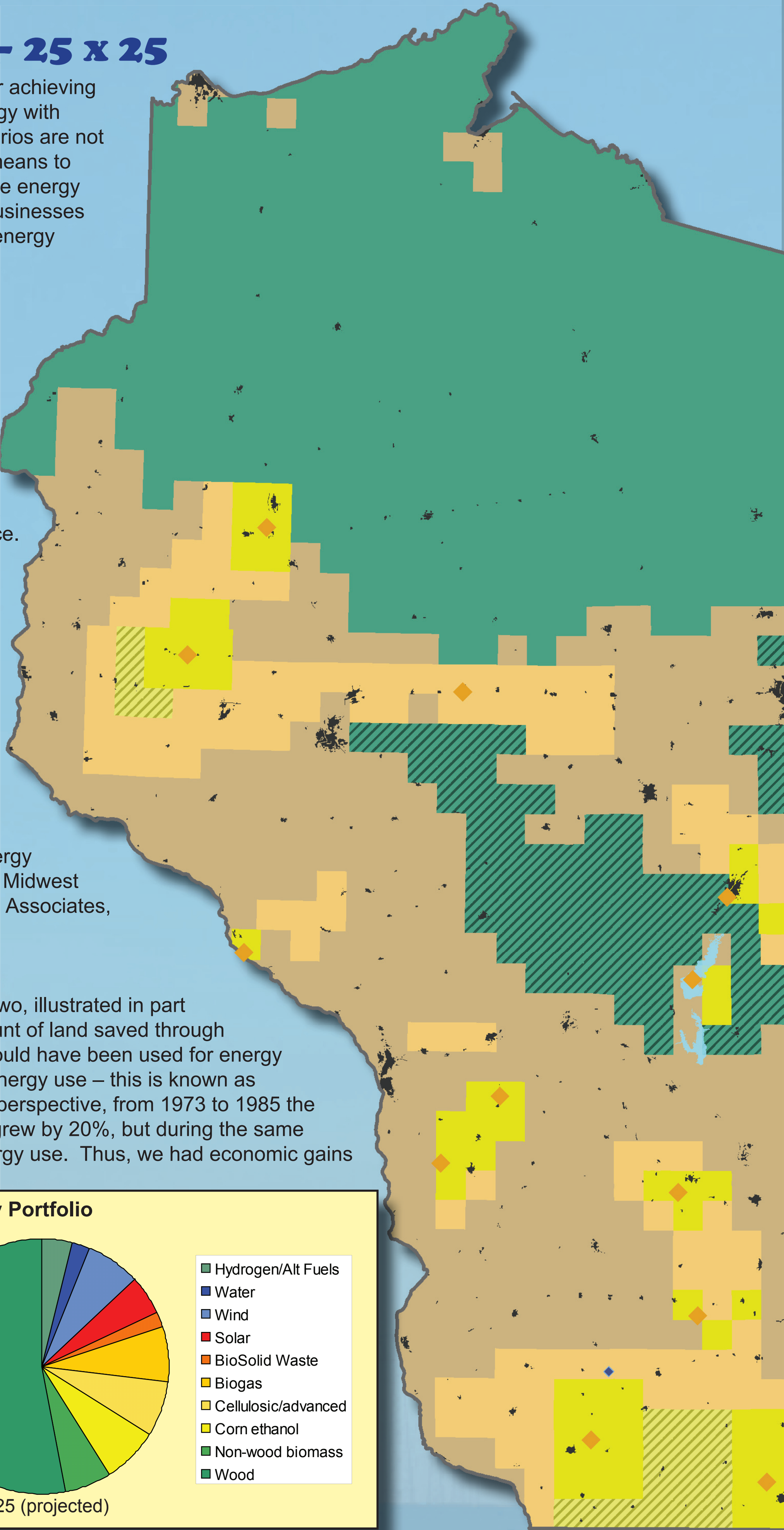
In 2005, 1.2 million acres of corn were used to produce corn ethanol of which approximately two-thirds was exported. By 2025, under scenario one, Wisconsin may need 900,000 acres of land devoted to ethanol production, which does not include any exports. Under scenario two, over 1.2 million acres of farmland may need to be devoted to ethanol production – none of it exported. In 2005, Wisconsin harvested 2.9 million acres of field corn.[9]

Wind and photovoltaic solar require relatively small amounts of land in these scenarios, with wind requiring approximately 114,000 acres under scenario one and 151,000 acres under scenario two.[10] Photovoltaic solar would require approximately 11,000 acres under scenario one and 15,000 acres under scenario two with the acreage largely comprising rooftops.

The total amount of land required to achieve the state's 25% renewable energy goal by 2025 is 12 million acres (35% of Wisconsin's land) under scenario one and 16 million acres (46% of Wisconsin's land) under scenario two. This equates to a difference of 4 million acres of land.

Land Use Scenario – 25 x 25

Map 2 focuses on two land use scenarios for achieving the state's goal of producing 25% of its energy with renewable resources by 2025. These scenarios are not predictive of the future. Rather, they are a means to initiate a dialogue about the role of renewable energy and energy efficiency within communities, businesses and households in order to achieve a more energy independent future.



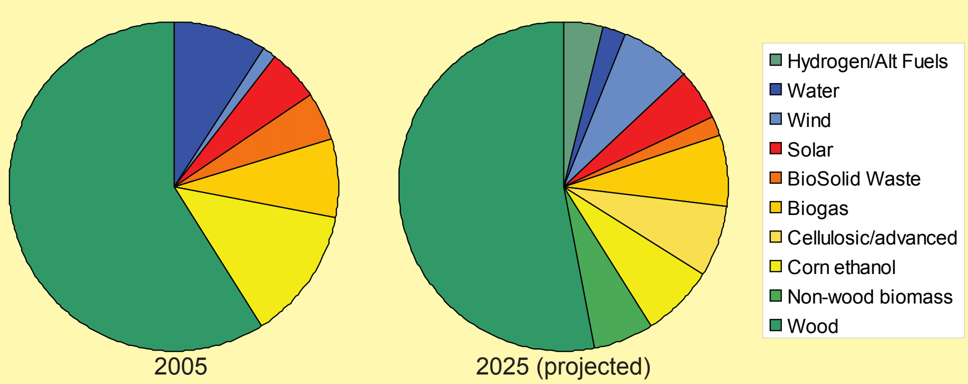
Assumptions

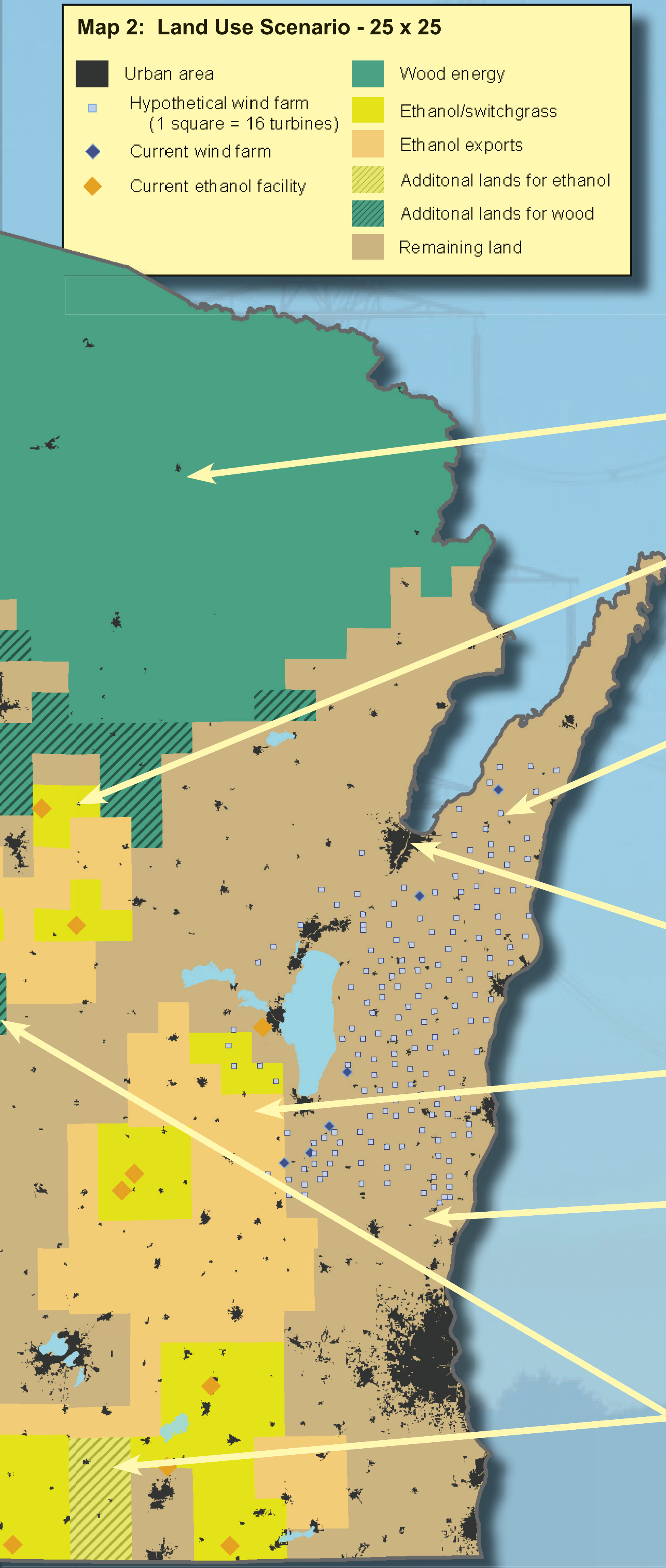
These scenarios are based on a number of assumptions regarding the type and percentage of renewable uses available in 2025, as well as the land use acreage or "footprint" required for those uses. Figure 9 shows the state's current renewable portfolio compared to what might be required in 2025 as provided by the Wisconsin Office of Energy Independence. These projections assume continued growth in the use of wood, a significant expansion of wind generation (by a factor of about 10), continued loss of hydroelectric power, and relatively small increases in solar. Growth is also projected in the development of non-wood biomass, cellulosic and advanced biofuels, and other alternative fuels. Fuels that consume a significant amount of land – primarily wood, wind, solar and various forms of biofuels – were translated to land use acreages based on information from the Wisconsin Office of Energy Independence, Wisconsin Focus on Energy, Midwest Renewable Energy Association, and Wilinski Associates, Inc.

Implications

The difference between scenarios one and two, illustrated in part by the hashed lines on this map, is the amount of land saved through energy efficiency. Theoretically, land that would have been used for energy production remains as is or is put to a non-energy use – this is known as *negawatts* (negative watts). To put this into perspective, from 1973 to 1985 the gross national product of the United States grew by 20%, but during the same period the U.S. had near zero growth in energy use. Thus, we had economic gains

Figure 9: Wisconsin Renewable Energy Portfolio





with no growth in energy use largely because of increases in energy efficiency.[11] To achieve energy efficiency at this scale means changing individual, household, institutional and business behavior in our use of energy for heating and cooling, electricity and transportation.

The tradeoffs evident in these growth scenarios underscore the need to consider land use prioritization as it pertains to energy use. What is an appropriate mix and arrangement of land uses in local communities? To what purpose should Wisconsin use its public and private forest lands? How can Wisconsin ensure that its forested land is sustainably harvested?

Forests
(Projected to provide 53% of renewable energy in 2025.)
A total of 10.2 million acres or roughly the size of Wisconsin's Northwoods of forestland would need to be sustainably harvested to meet the 2025 goal.

Corn and cellulosic ethanol and non-wood biomass fuel
(Projected to produce 20% of renewable energy in 2025.)
Nearly 2 million acres of land would be dedicated to corn and switchgrass for energy use in Wisconsin. We selected areas surrounding current ethanol facilities and assumed the land dedicated to corn would have corn grown there 4 out of every 5 years.

Wind
(Projected to provide 7% of renewable energy in 2025.)
A total of 114,000 acres of land is needed to achieve the 2025 goal for wind energy. Each box is 640 acres in size and represents 16 turbines, assuming that each tower requires 40 acres of land. Random locations were selected throughout the high winds region of Wisconsin.

Solar
(Projected to provide 5% of renewable energy in 2025.)
Urban surfaces cover about 600,000 acres in Wisconsin. Less than 2%, or 11,000 acres, of that area could produce enough solar energy to meet our goal.

Ethanol exports
Wisconsin currently exports 2/3 of its annual ethanol production. If that same proportion is exported in 2025, an additional 3.5 million acres of farmland will be devoted to corn or switchgrass.

Land not used for energy production
If we continue to export ethanol at today's rate, then the total amount of remaining land is roughly 14 million acres. Of that, about 3.6 million is unavailable, representing water, wetlands, and currently developed lands. The remaining 10.4 million acres (30% of the land in Wisconsin) must provide sufficient space for food and fiber production, homes, parks, recreation, and habitat.

Additional land needed assuming no energy efficiency
If we continue to increase our energy consumption at the current pace of 18 trillion Btus per year, with no energy efficiency, an additional 3.3 million acres of forests and 650,000 acres of farmland will be needed for renewable energy production.

Land Use Approaches to Reduce Energy Use

There are numerous opportunities to save energy by modifying the manner in which we plan and build our communities; site, design, build and operate our homes, businesses and public buildings; and design and use our transportation systems. By reducing the total energy requirements of the U.S. economy, improved energy efficiency will make increased reliance on renewable energy sources more practical and affordable.[7]

Building Design

According to the U.S. Department of Energy, almost three-quarters of our nation's 81 million buildings were built before 1979. Some were designed and constructed for limited service and many will require significant retrofits or replacements. An additional 15 million new buildings are projected to be built by 2010. Today's buildings consume more energy than any other sector of the U.S. economy including transportation and industry. They account for: 65% of electricity consumption, 36% of energy use, 30% of greenhouse gas emissions, 30% of raw material use, and 30% of waste output. Designing energy efficient buildings and selecting energy efficient appliances can make a major impact on decreasing our energy use.

From 2001-2006, Wisconsin's Focus on Energy programs helped 38,400 businesses and 547,224 households in Wisconsin save over $129 million in energy costs. Of these savings, 57% were achieved by businesses, 36% by residential users and 6% through renewable energy installments.[12,13] The largest energy savings came from converting to more efficient lighting and heating systems and adding insulation.[12] The energy savings during this time period was 3.1 trillion Btus annually, which equates to approximately 1% of the total energy use in Wisconsin.[12,14,15] In 2004, Wisconsin's per capita spending of $9.76 on Focus on Energy programs was moderate compared to a high of $22.54 per capita on energy efficiency programs in Vermont.[6]

According to Focus on Energy, "in a typical house, over 40% of the annual energy budget is consumed by heating and cooling, so choosing the right insulation and installing it correctly are important steps in home efficiency, especially here in Wisconsin."[16] In general, the older the home, the more likely it is to be under-insulated or have high air leakage.[17] Insulating a building involves air sealing, insulation, and window weatherstripping or replacement. Energy-efficient heating and cooling systems also play a large role in achieving energy efficient buildings.

How much energy a home needs for heating depends on a variety of factors. Homes that are smaller, better insulated and sealed, and have more efficient heating systems use less energy.[17,18,19] Another factor affecting home energy use is whether a home is in a single-family or multi-family building. Most large multifamily buildings were built after 1970. Partly because of this—but also because they enclose a larger volume per square foot of surface area—these apartment buildings use far less heating energy per square foot than smaller buildings.[18]

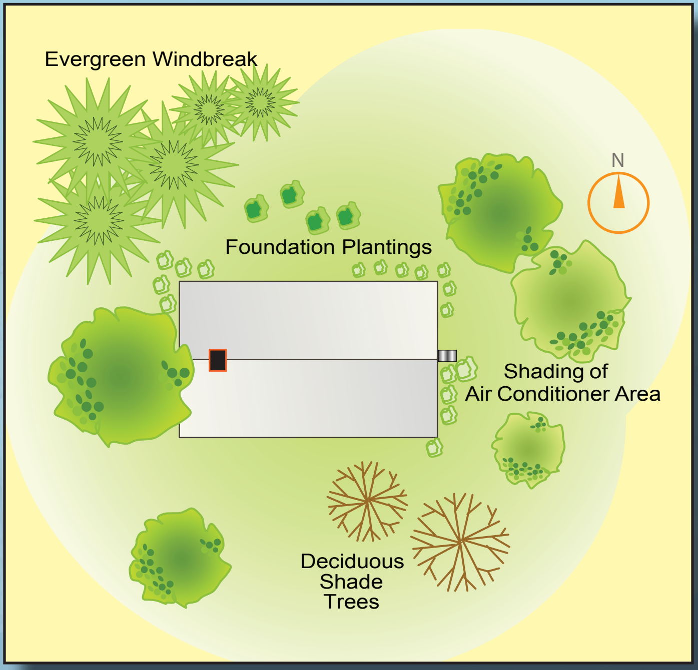
The integration of efficiency with renewable energy maximizes the benefits of both. For example, the correct building orientation can save up to 20 percent of heating costs; those savings can jump to 75 percent when renewable energy and appropriate insulation are integrated into the building.[7]

Reducing electric use is also important. Building design can reduce electric use in homes by reducing the need for air conditioning, optimizing natural light use, and avoiding electric heating or electric hot water heaters.

Landscaping

The right trees planted in the right place can reduce energy costs for summer cooling and winter heating (see Figure 10). In midsummer, the sun shines on the east side of a building in the morning, passes over the roof near midday, and then shines on the west side in the afternoon. Electricity use is highest during the afternoon when temperatures are warmest and incoming sunshine is greatest. Therefore, the west side of a home is the most important side to shade. Depending on building orientation and window placement, sun shining through windows can heat a home quickly during the morning hours. The east side is the second most important side to shade when considering the net impact of tree shade on cooling and heating costs. Deciduous trees on the east side provide summer shade and more winter solar heat

Figure 10: Deciduous shade trees, evergreen windbreaks and foundation plantings can reduce heating and cooling costs while providing for solar access.



gain than evergreens (see Figure 11). A yard tree located south of a building produces the least net energy benefit because it has the least benefit during summer and the greatest adverse effect from shade on heating costs in winter.[20]

Trees provide greater energy savings in the Midwest region than in milder climate regions because they can have greater effects during the cold winters and warm summers. An average energy-efficient home with an air conditioner in Minneapolis, Minnesota, spends about $750 each year for heating and $72 for cooling. A computer simulation demonstrated that wind protection from three 25-ft-tall trees—two on the west side and one on the east side of the house—would save $25 each year for heating. Shade and lower air temperatures from the same three trees during summer reduced annual cooling costs by $40. The total $65 savings represented an 8 percent reduction in annual heating and cooling costs.[20]

While energy savings tend to increase with tree size, foundation plantings of shrubs and small trees can also significantly reduce energy costs. In addition to reducing the amount of wind that actually hits a home, shrubs planted next to the house can provide insulation because they create a dead airspace next to the foundation.[21]

At a community level, local governments can facilitate energy savings for landowners through their forestry programs and the codes they adopt related to landscaping. For example, the City of Stevens Point Forestry Department estimates that their 7,100 city-owned street trees save residents over $163,000 annually in energy savings.[22] Local governments can also partner with utilities or other groups to fund or publicize incentives for planting trees and shrubs in optimum locations for energy efficiency. At least 10 local utilities in Wisconsin that are part of Wisconsin Public Power Inc. offer up to $50 per tree for new plantings that meet their specifications for energy efficiency.[23]

Solar and Wind Access Laws

While trees in the right place can reduce energy costs, trees in the wrong place can have the opposite effect, especially as they affect renewable energy systems. Wisconsin state law allows counties, cities, villages and towns to adopt an ordinance to require the trimming of vegetation that blocks solar energy from a collector surface, or that blocks wind from a wind energy system. State law also prevents local governments from restricting the installation of solar or wind energy systems unless the restriction does one of the following:

- protects public health or safety
- does not significantly increase the cost of the system or decrease its efficiency
- allows for an alternative system of comparable cost and efficiency.[24]

This leaves local governments in Wisconsin with a wide range of options in regulating local energy systems. As an example, Madison's land subdivision regulations require streets to be "oriented in an east-west direction to the maximum extent possible" to facilitate solar access.[25]

The flexibility of Wisconsin's statutes has resulted in a patchwork of regulations. In contrast, Minnesota adopted statewide uniform standards for siting wind systems in 2002.[26] At the time of this publication, the Wisconsin Governor's Task Force on Global Warming is recommending similar legislation for Wisconsin.[27] In the meantime, a group of Wisconsin agencies and organizations have developed a Small Wind Energy System Model Ordinance that local governments may use as a guide to address this issue in their communities.[28]

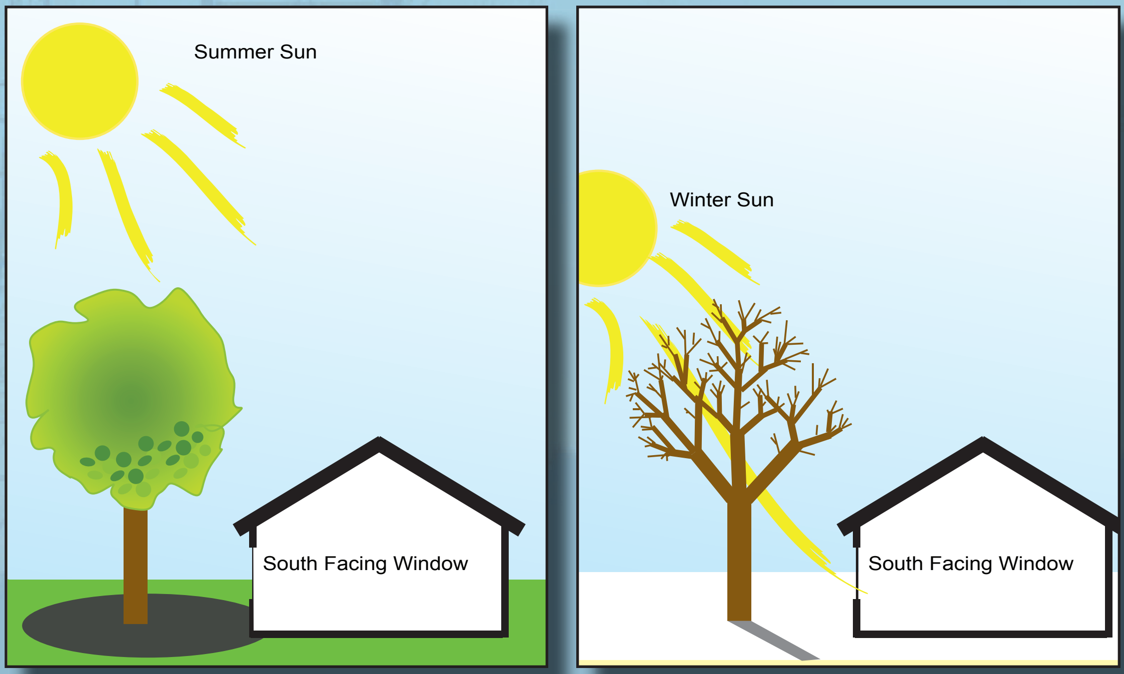
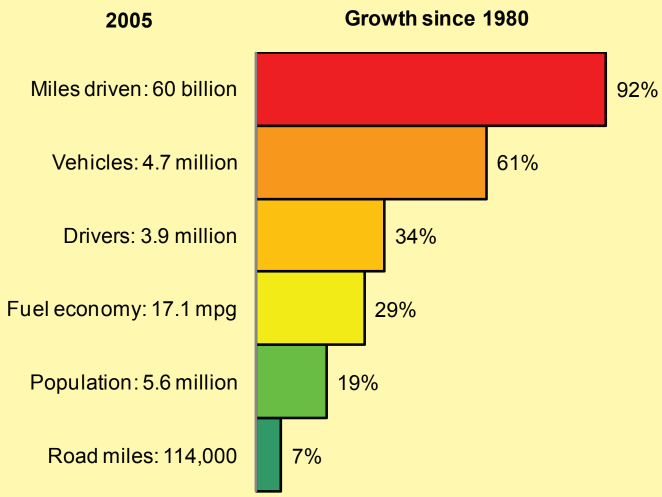


Figure 11: Deciduous trees allow light to penetrate during the winter when the sun is lower in the sky.

Energy and Transportation

Between 1980 and 2005, mileage driven in Wisconsin increased at a rate nearly three times as fast as licensed drivers, five times as fast as population, and fifteen times as fast as road miles (see Figure 12). During this time period, total motor fuel consumption for transportation increased from 2.5 to 3.3 billion gallons. Gains in fuel efficiency (29%) were offset by significant increases in driving (92%) and a trend toward more energy-intensive forms of transportation.

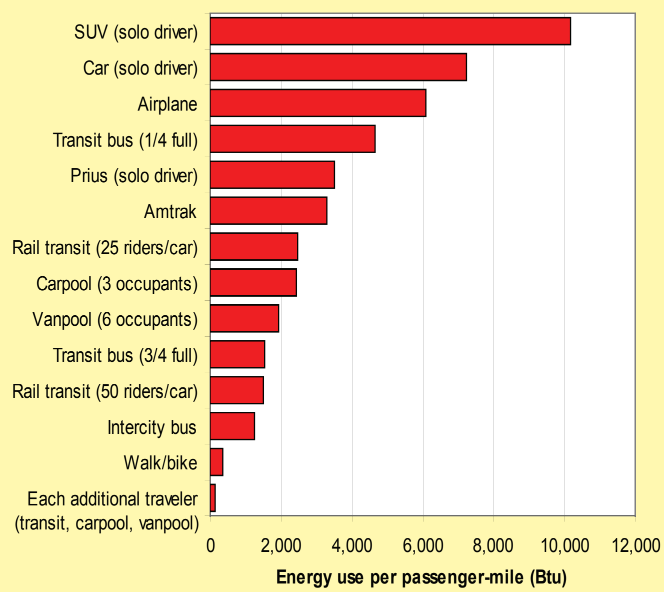
Figure 12: Wisconsin Highway Statistics, 1980-2005[29]



In Wisconsin, the dominant form of transportation is the private automobile. Between 1980 and 2000, the share of commuters driving alone increased by nearly one-third, while levels of carpooling, public transportation and walking declined (see Figure 13). Nearly one-quarter of Wisconsin residents commute outside of their county of residence for work. These patterns are generally reflective of a dispersed automobile-dependent society.

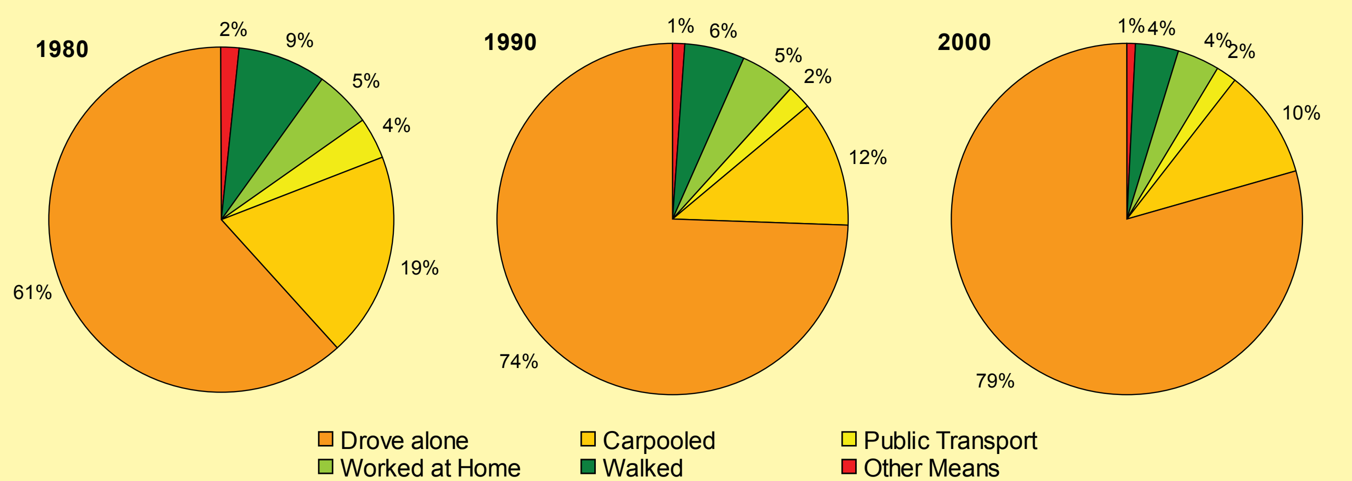
Figure 14 shows energy use per passenger mile for various modes of transportation. Private automobile use ranks as the most energy-consumptive form of transportation, while public transit, carpooling, walking and biking provide considerable gains in fuel efficiency. The Wisconsin Department of Transportation distributes funds for public transit and bicycle and pedestrian facilities. However, there is no agency or organization in Wisconsin that provides site-specific assistance to communities to reduce energy use related to private automobile use.

Figure 14: Energy Consumption by Travel Type[31]



Stabilizing or reducing transportation energy can be accomplished by reducing distances traveled, using more efficient means of transportation, or both. Community design can facilitate both of these approaches.

Figure 13: Wisconsin Commuting Patterns, 1980-2000[30]



Community Design

Trends in transportation energy use are influenced by the manner in which we design our communities. In the past, transportation professionals tried to improve transportation by increasing vehicle traffic speed and road capacity. Unfortunately, this resulted in greater use of the automobile, increased traffic congestion and greater levels of carbon dioxide emissions. Transportation planners are now partnering with land use planners to create walkable and bikeable neighborhoods, mixed use developments and transit oriented developments. The goal is to create desirable places to live while reducing the number of miles driven.

Density and Mixed Use Design

Genuinely walkable or bikeable communities provide adequate and safe infrastructure including sidewalks, bike paths and traffic calming measures, as well as attractive destinations such as shops and restaurants. Ensuring that these places are both walkable and economically viable requires density. Studies have shown that densities of seven housing units per acre or higher are needed to support a small corner store, while 18 units per acre are required for a small supermarket.[32] To encourage walking, destinations should be within a reasonable, 5-10 minute walk.[33]

With destinations close by, car trips are shorter, resulting in fewer vehicle miles driven. People can also choose to walk, bicycle or take transit at least some of the time. High density does not imply that entire neighborhoods or communities need to be uniformly dense. In fact, there is not a single community in Wisconsin that could support bus service if density were calculated based on total acres within the community. Communities that provide higher average "blended" densities featuring a mix of land uses, nearby employment centers, vibrant streetscapes, interconnected walkable/bikeable streets, and nearby access to common green space can make considerable gains in reducing transportation related energy use.

Transit Oriented Development

Transit Oriented Development (TOD) is a strategy to create land use patterns that support mass-transit and reduce automobile miles traveled. The focal point is the transit stop (bus, train, trolley, etc.) which is surrounded by relatively high levels of residential and commercial development. Urban TODs are normally constructed with a minimum density of 12 dwelling units per acre (DU/acre) or an average density of 18 DU/acre. Neighborhood and rural TODs are designed with a minimum density of 7 DU/acre or an average of 10 DU/acre. The average size of the development is based on an approximate 10 minute walk from the transit stop (or a radius of 1,300-2,000 feet around the transit stop). TODs can be created as new developments or as a result of restoration and infill in existing developments. This pedestrian-friendly design can result in one-third fewer miles driven by its residents.[34]

LEED for Neighborhood Development

The Leadership in Energy and Environmental Design for Neighborhood Development (LEED ND)[35] program is a voluntary certification program by the U.S. Green Building Council that sets standards for neighborhood location and design. Emphasis is placed on design and construction elements that bring buildings together into a neighborhood, and relate the neighborhood to its larger region and landscape. The goal of the program is to encourage developers to revitalize existing urban areas, reduce land consumption, reduce automobile dependence, promote pedestrian activity, improve air quality, decrease polluted stormwater runoff, and build more livable, sustainable, communities for people of all income levels. Key components of the program include: design for walking, biking and mass transit; energy efficiency in buildings and infrastructure; heat island reduction; and solar orientation and on-site renewable energy generation.

Figure 15: Density Required to Support Public Transit[36]

7-8 housing units per acre as shown in this single-family development can support bus service every 30 minutes.

18-20 housing units per acre as shown in this neighborhood with a mix of high rise, duplex and single family housing can support a transit station.

30+ housing units per acre as shown in this low-rise multi-family development can support high-frequency transit service every 10 minutes

Photos: Visualizing Density, Lincoln Institute of Land Policy

References

1 This is a cartographic representation of Wisconsin's energy infrastructure. The geographic shape and location of graphic features have been generalized and modified to improve graphic interpretation at this scale. Petroleum pipelines and coal transportation routes scanned and digitized from maps contained in the 2007 Wisconsin Energy Statistics report produced by the Wisconsin Office of Energy Independence. Natural gas pipelines, electricity transmission corridors, and power generation facility data provided by the Public Service Commission of Wisconsin, March 2008. Manure digester data provided by Joe Kramer, Energy Center of Wisconsin, forthcoming summer 2008 in the Wisconsin Agricultural Biogas Casebook.
2 Wisconsin Office of Energy Independence. Wisconsin Energy Statistics 2007. http://power.wisconsin.gov.
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4 2005 energy expenditures calculated based on costs of individual fuels.
5 Jenkins, David. Personal communication, 3/18/08. Renewable energy production and consumption in Wisconsin are similar, except approximately two-thirds of ethanol produced in Wisconsin is exported.
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