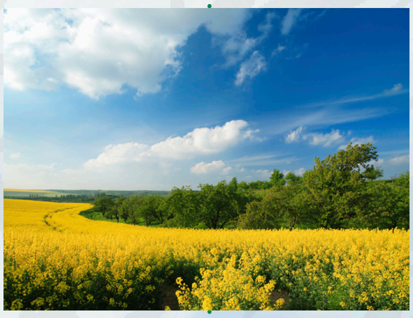
25x'25 Roadmap for Kentucky

Charting Kentucky's Renewable Energy Future



KREC

Kentucky Rural Energy Consortium

25x'25 Roadmap for Kentucky

Authorship

This Roadmap report was prepared for the Kentucky Rural Energy Consortium (KREC) by the Kentucky Pollution Prevention Center, J.B. Speed School of Engineering, University of Louisville; and the University of Kentucky, College of Agriculture.

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Executive Summary

The Kentucky Rural Energy Consortium (KREC) developed the Kentucky 25x'25 Roadmap to recommend and support an ambitious, yet achievable energy goal for the Commonwealth :

"By the year 2025, Kentucky will use renewable energy and energy efficiency as means to get at least 25 percent of its total energy from improved technologies and renewable resources such as solar, wind, biomass and biofuels."

Why 25x'25?

Kentucky's, and the nation's, prosperity depends on having a reliable supply of clean, sustainable energy now and far into the future. Yet world events, climate change, uncertain supplies, and an ever-growing global demand for fossil fuels have converged to place our collective energy future in jeopardy. It is now obvious that we can no longer count on a limitless supply of inexpensive fossil fuel to meet our future energy needs.

Responding effectively to the world's new energy realities will be one of the most urgent and important challenges of our time. To meet this challenge, we must identify and pursue aggressive, yet achievable, solutions to meet our energy needs. Now, more than ever, there are abundant new business opportunities in safe, clean energy alternatives. New innovative ideas are emerging every day, while both private and public investments in alternative energy research and development and energy efficiency technologies are growing at a rapid pace.

Kentucky is beginning to respond to these challenges in a number of ways. Just within the past two years, the Kentucky General Assembly enacted HB 299, HB 1 and HB2. These bills established a variety of mechanisms to promote renewable energy projects and energy efficiency technologies within the state and serve as a solid foundation upon which to build an effective statewide energy policy. Private industry in Kentucky is moving forward with significant investments in biodiesel and ethanol production facilities, and research efforts are underway at Kentucky universities to develop new bio-processing techniques, examine wind and solar potential, and advance improved energy efficiency technologies and practices.

KREC believes that the 25x'25 goal is certainly achievable, but will require a high level of cooperation and collaborative effort among many diverse stakeholders – state leaders, policy makers, advocacy groups, the agricultural community, commercial energy developers, financial institutions, and the public will need to work together to overcome the challenges of financial barriers, regulatory restrictions and a lack of public understanding about emerging energy technologies.

The Kentucky 25x'25 Roadmap was created as a guide for stakeholders to find common ground for cooperation and to provide information vital to future planning and decision-making. The Roadmap does not prescribe a single path forward or a quick fix for our energy needs. Instead, it offers a range of options – many already vetted by those with a stake in the transition – for seizing existing opportunities and initiating new ones. The Commonwealth already enjoys many comparative advantages in energy production, including a strong natural resource base, a highly qualified community of educators and researchers, and the commitment of its state government to achieving energy independence. Building on these advantages, while encouraging innovation and ingenuity, will help Kentucky move forward to a secure energy future.

As detailed in section five of this Roadmap report (Kentucky's Resources to Meet the Needs of the 25x'25 Initiative), the potential in Kentucky for achieving energy demand reduction, biofuel production, and a reduction in CO_2 emissions is significant.

To realize this potential, KREC has developed near-term recommendations to help begin the process and to guide Kentucky toward achieving the 25x'25 goal of economic development and energy security.

1. **Support the Center for Renewable Energy Research and Environmental Stewardship**

   It is vital to Kentucky's energy future that the newly created center of excellence for renewable energy and energy efficiency be supported, properly funded, and held accountable for results. House Bill 2, recently passed by the Kentucky General Assembly, established the **Center for Renewable Energy Research and Environmental Stewardship** (CRERES). KREC's Advisory Board is encouraged by this legislation and supports the center's mission and goals. The establishment of CRERES should advance the efforts of research, development, demonstration and commercialization of renewable energy, biomass co-products, and energy efficiency technologies and practices that benefit Kentucky. The center should be funded with state funds at an adequate and consistent level to ensure a vital, effective center that produces results.

   We encourage our state leadership to build upon the success of the KREC model as they develop this important Kentucky center of excellence. Governance of the center should include a balance between representatives from Kentucky's public universities, the legislative and executive branches, renewable energy and energy efficiency advocates, Kentucky's agriculture community, and renewable energy business and industry stakeholders.

2. **Increase the Level of Highly Qualified Renewable Energy and Energy Efficiency Expertise**

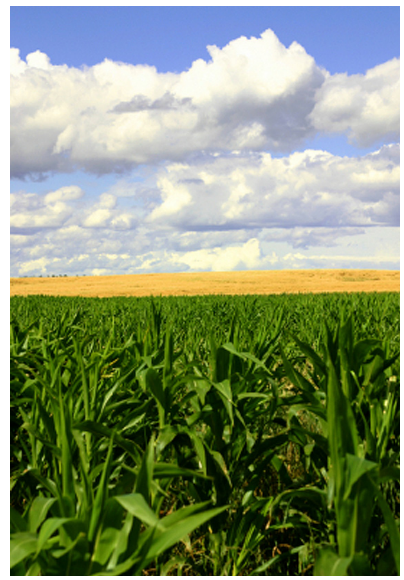
   It is vital to Kentucky's energy future that incentives be created for increasing the number of highly qualified renewable energy and energy efficiency faculty and researchers at state universities.

3. **Establish Renewable Energy and Energy Efficiency Outreach Programs**

   It is vital to Kentucky's energy future that a statewide public awareness and education program be established using the Cooperative Extension Service to develop and disseminate curriculum and other educational materials on renewable energy opportunities and energy efficiency savings. Partnering agencies and programs would include, but not be limited to: 4H, Future Farmers of America (FFA), Kentucky Department of Agriculture, Ag in the Classroom, the National Energy Education Development (NEED) project, and the Kentucky Energy Efficiency Program for Schools (KEEPS).

4. **Encourage Energy Efficient Homes and Buildings**

   It is vital to Kentucky's energy future that all new buildings built for the Executive Branch, Judicial Branch, and public universities be required to meet or exceed ENERGY STAR® certification requirements in design and construction. Through state incentives, encourage home builders to build



Harnessing Kentucky's extensive resources and ingenuity can provide energy security for our state and nation, create jobs, and stimulate economic development.

Roadmap Findings:

- Kentucky has an abundance of natural resources that could produce as much as 78 trillion Btus of energy by 2025
- Kentucky's energy savings potential is significant. By 2025, the state could save as much as 279 trillion Btus of energy in residential and commercial use and vehicle fuel economy, saving consumers an estimated $700 million in electricity and natural gas.
- Production and distribution of ethanol could add as much as $1 billion to the state's economy by 2025.
- Acting on Kentucky's potential for ethanol fuel production could result in more than 4,000 new jobs, new tax revenue of $3 million per year, and value-added benefits of $486 million.
- Kentucky's potential ethanol production from corn, switchgrass and agricultural residue could supply 668 million gallons of fuel per year – 21.4% of the total 2004 consumption.
- Kentucky's potential biodiesel production from existing oil seed crops could supply the equivalent of 107 million gallons of petroleum diesel per year – 8% of Kentucky's total consumption in 2004.

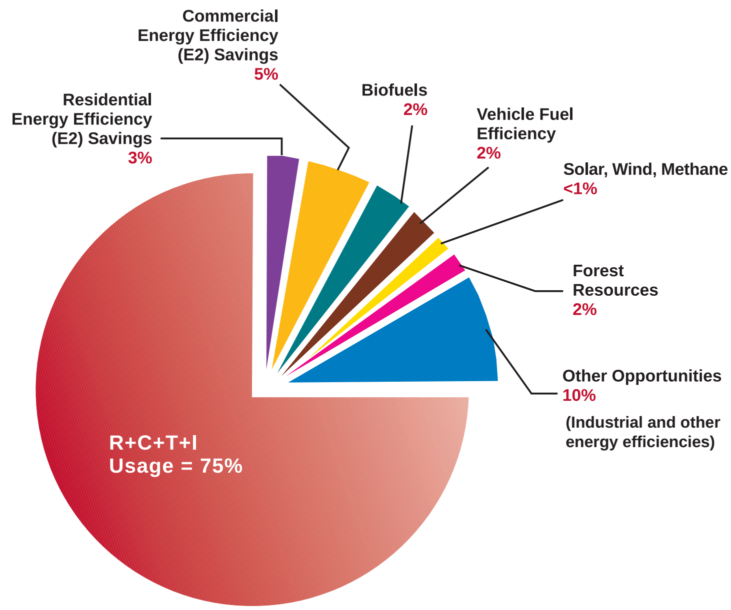
homes that meet or exceed ENERGY STAR® certification requirements. Provide state incentives for homeowners to improve the energy efficiency of their own homes, thus improving overall efficiency of the state's existing housing stock.

5. Support Expanded Use of Biofuels

It is vital to Kentucky's energy future that state agencies and public universities that operate state-owned vehicle fleets be required to adhere to a renewable fuel standard (RFS), and use ethanol and biodiesel fuels whenever possible. State agencies should be held accountable for achieving RFS targets.

How We Get There

The pie chart below, from section four of the Roadmap, shows those sectors of our energy mix that have the potential to get us to the 25x'25 goal. Energy efficiency measures for residential, commercial, and industrial operations, as well as vehicle miles per gallon improvements, have the potential to contribute as much as 19% of the total 25% goal. Biofuels, solar, wind, methane and forest resources could provide the balance, with ethanol production alone adding as much as $1.1 billion annually to the state's economy.



With this 25x'25 Roadmap, the KREC Advisory Board sets out an important part of its strategic vision for the energy future of Kentucky. It seeks to significantly accelerate the growth in renewable energy, and proposes that the Commonwealth achieve a contribution of 25% of its energy mix from renewable energy sources and energy efficiency efforts by 2025. KREC requests that the State Legislature, the Governor, utility companies, the PSC, the Attorney General, environmental groups and other consumer, commercial, and public sector stakeholders endorse this target goal.

The Kentucky Rural Energy Consortium

The Kentucky Rural Energy Supply Program was established in 2005 by a federal direct appropriation from U.S. Senator Mitch McConnell to benefit Commonwealth citizens by creating a unified statewide consortium to promote renewable energy and energy efficiency in Kentucky. The Kentucky Rural Energy Consortium (KREC), formed at the outset of the program, seeks to advance comprehensive research on biomass, bioenergy and energy efficiency of importance to Kentucky agriculture, rural communities, and related industries. KREC is a partnership of the University of Louisville's Kentucky Pollution Prevention Center and J.B. Speed School of Engineering; University of Kentucky's College of Agriculture, College of Engineering, and Center for Applied Energy Research; other Kentucky Universities; the Governor's Office of Energy Policy and other key state agencies; and agricultural commodities groups and industry partners. The Consortium is strongly supported by leaders in agribusiness, government, and universities.

KREC's executive staff and Advisory Board have recently concluded administration of a $2 million operational grant. With this funding, KREC organized and conducted a competitive grants program aimed at fundamental and applied research of importance to Kentucky. Proposals were requested for projects dealing with renewable energy, energy efficiency, and production of bioenergy or biochemicals from biomass feedstocks. Specific areas of research included harvesting and storage of lignocellulosic feedstocks; biocatalysts and bioconversion of lignocellulosic feedstocks into liquid transportation fuels and bioproducts; thermal conversion of biomass into energy and co-products; conversion of solar energy through new technology applications; development of energy efficiency technologies; and industrially important biochemicals for production in biorefineries.

KREC's goal is to advance comprehensive research on renewable energy and energy efficiency, and to highlight the importance of these research efforts to Kentucky's agriculture, rural communities, and related industries. The research goals for KREC include dramatically reducing our nation's dependency on foreign oil, and creating an economically viable renewable energy industry in the Commonwealth.

The National 25 x '25 Initiative: Purpose & Policy

The National 25x'25 organization is a grassroots renewable energy initiative backed by businesses, organizations, and individuals united by a common interest in making America's energy future more secure, affordable and environmentally sustainable. KREC, as a supporting partner of the National 25x'25 Initiative, joins the Kentucky Department of Agriculture, Kentucky Farm Bureau, the Kentucky House of Representatives and the former governor of Kentucky in endorsing the 25x'25 goals and principles.

KREC's Mission:

- Conduct, sponsor, and coordinate research to develop biomass, bioproducts, and energy efficiency technologies of importance to Kentucky.
- Serve as a model for state efforts to decrease dependence on imported fuels, increase energy efficiency, and to increase reliance on energy production from biomass resources.
- Seek out opportunities and funding to provide research activities for energy efficiency, biomass and bioproducts.
- Serve as a clearinghouse and networking group to exchange knowledge, programs, and ongoing activities of the Consortium and related state and federal programs. Build partnerships throughout the Commonwealth that support stated goals and federal biomass initiatives.
- Provide a forum for discussing the national 25x'25 initiative in Kentucky and develop a Kentucky 25x'25 Roadmap report.

The goals of the 25x'25 National Initiative are consistent with the Kentucky Rural Energy Consortium's efforts to support, coordinate, promote, and advance research, development, demonstration and deployment of renewable energy and energy efficiency technologies, practices, and outreach activities of importance to Kentucky.

The national 25x'25 program's vision statement:

By 2025, America's farms, forests and ranches will provide 25 percent of the total energy consumed in the United States, while continuing to produce safe, abundant, and affordable food, feed and fiber.

The national initiative identifies six principles for getting the nation to a 25x'25 future:

First, energy efficiency improvements must be the option of first choice in all energy decisions.

Second, the production of renewable energy must increase dramatically. After efficiency, renewable sources will be the first choice for electricity generation where it is safe, reliable and affordable. Meeting the 25x'25 goal will further lower the costs of renewable energy so that it is competitive with fossil fuels, and lead to the development of a new array of value-added renewable products.

Third, the delivery of renewable energy to markets must be a key area of focus. The 25x'25 vision calls for the creation of an expanded network of infrastructure and facilities. Transmission and distribution systems should be expanded and better managed. All renewable electricity producers should gain access to the grid to get power to markets, expanding distributed generation of power produced locally.

Fourth, a renewable energy market must be built by increasing consumer demand for biofuels and renewable electricity. This can be accomplished by boosting the number of flex-fueled vehicles (FFV) that can run on either biofuels or gasoline, expanding the number of biofuels pumps to deliver fuel to the customer, simplifying consumer purchase of renewable energy, and creating interstate markets for renewable energy credits.

Fifth, natural resources must be conserved, protected, and enhanced by using practices and systems that maintain or improve soil, water, and air quality; conserve water; reduce invasive species; and improve wildlife habitat through the production of biomass.

Finally, funding to develop renewable energy must be increased. A significant private and public investment in renewable energy must be made in order to achieve the 25x'25 goals.

More information about the national organization can be found at www.25x25.org.

While the 25x'25 initiative in Kentucky has much in common with the national 25x'25 organization's goals and vision, Kentucky is unique in its land resources, climate, geography, regional setting and political climate. The Kentucky 25x'25 Roadmap identifies its own set of goals and founding principles to help guide the state toward expanded economic opportunities and a more secure energy future.

25x'25 Roadmap for Kentucky

The KREC team believes that Kentucky can generate more than 25 percent of its total energy needs from renewable energy sources by the year 2025, if a priority is placed on supporting the most promising renewable energy and energy efficiency sectors and technologies.

Three "Town Hall" meetings were held in Frankfort, Somerset, and Princeton, Kentucky to gather input for the 25x'25 Roadmap. Attendees represented farming, forestry, and university research, as well as U.S. Congressional offices. Local farmers, ranchers, business people, Kentucky agricultural extension agents, and alternative energy producers also contributed to the meetings.

In early 2007, the Kentucky Rural Energy Consortium convened a diverse group of stakeholders and launched a state-wide renewable energy and energy efficiency initiative. The vision of the Consortium was to promote and recommend an ambitious goal for the Commonwealth; *"By the year 2025, Kentucky will use renewable energy and energy efficiency as means to get at least 25 percent of its total energy from improved technologies and renewable resources such as solar, wind, biomass and biofuels."*

The majority of this renewable energy could be derived from Kentucky's farm and forest resources, thereby creating significant economic opportunities in rural communities and stimulating the state's agricultural industries.

Energy efficiency efforts can also produce significant savings and contribute to the overall 25x'25 goal while providing a wide array of economic and environmental benefits to Kentucky's residential, commercial and industrial sectors and to the state as a whole. Deploying comprehensive energy efficiency technologies and programs is critical to achieving substantial energy use reductions by 2025. If energy efficiency measures are implemented broadly and aggressively over the next 18 years, efficiency efforts alone could account for as much as 19% of the 25% total energy goal.

The development phase of Kentucky's 25x'25 Roadmap report was consensus driven. Three "Town Hall" meetings were held across the state to gather public input for the 25x'25 Roadmap development process. These public meetings were held in Frankfort, Somerset, and Princeton, and the hundreds of citizens who joined the meetings brought many innovative and entrepreneurial ideas, as well as some important criticisms of current and proposed energy policies. In addition to the public meetings, an energy survey was sent to KREC members and to industry and government leaders to establish a baseline of current renewable energy efforts across the state and gather new ideas for consideration in the 25x'25 Roadmap.

The Kentucky 25x'25 Roadmap is organized into five sections:

1. Kentucky's current and projected energy use;
2. Kentucky's natural resource base advantages;
3. Kentucky's energy targets for 2025;
4. Recommendations to reach the Kentucky 25x'25 goal, and;
5. A "White Paper" on *Kentucky Resources to Meet the Energy Needs of the 25x'25 Initiative.*

Section One - Kentucky's Current and Projected Energy Use

In order to reach the 25x'25 goal for the Commonwealth, it is important to understand where Kentucky gets its energy now, and what impact renewable energy and energy efficiency efforts might have on the state's future energy mix.

This section will examine Kentucky's current energy use and projected energy usage in 2025, and the potential for savings through energy efficiency measures.

As Figure 1 indicates, coal, natural gas, and petroleum account for 97% of total energy consumption. Roughly 3% of the energy consumed in Kentucky comes from hydroelectric or renewable sources.

Kentucky's per capita consumption of residential electricity is among the highest and their rates among the lowest in the United States. The 2005 annual site energy usage in Kentucky was 472.3 million Btu per person[1], making it the 8th highest state energy consumer in the U.S. The annual energy expenditures for Kentucky was $3,353/person making it 11th nationwide even though it ranked 44th nationwide in energy prices. While part of this discrepancy could be attributed to some very high energy use industries, it is evident that personal energy expenditures were high.

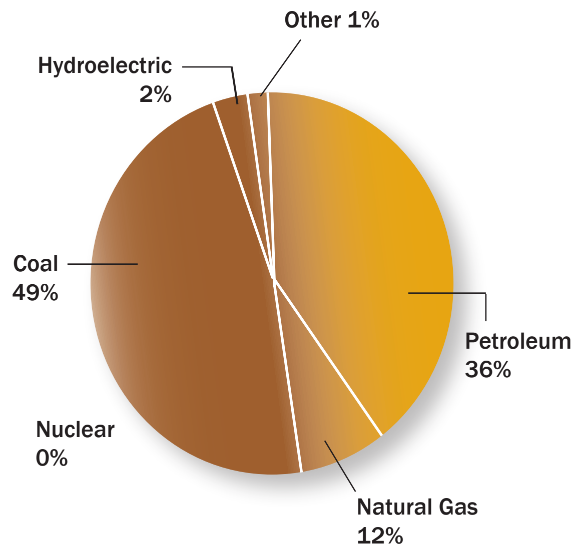


Figure 1. Kentucky's Energy Consumption by Source – 2005

Source: Energy Information Administration.
Table 7, Energy Consumption Estimates by Source, 2005

Petroleum

Kentucky receives petroleum products by pipeline and river barge. The state's total petroleum consumption is high (133,524 thousand barrels per year in 2005) relative to its population. The Louisville metropolitan area and the Kentucky suburbs of Cincinnati require reformulated motor gasoline blended with ethanol [2].

Natural Gas

Kentucky's natural gas production, most of which comes from the Big Sandy field in eastern Kentucky, typically accounts for less than 1 percent of total annual U.S. natural gas production. The majority of Kentucky's natural gas demand is supplied by pipeline from the Gulf Coast. Industry is Kentucky's largest natural gas-consuming sector, accounting for about one-half of total natural gas consumption. More than two-fifths of Kentucky households use natural gas for home heating [3].

Coal

Kentucky is the third largest coal-producing state (after Wyoming and West Virginia). It accounts for roughly one-tenth of all U.S. coal production and nearly one-fourth of U.S. coal production east of the Mississippi River. Almost one-third of all the coal mines in the country are found in Kentucky, more than in any other state. With both surface and underground coal mines, large volumes of coal move in and out of Kentucky by railcar and river barge to more than two dozen states, most of which are on the East Coast and in

[1] Energy Consumption by Source and Total Consumption per Capita, Ranked by State 2005, in Table R2 of http://www.eia.doe.gov/emeu/states/sep_sum/plain_html/rank_use_per_cap.html

KREC recognizes the importance of Kentucky's existing fossil fuel industry base and the state's comparative advantages as an industry leader in these important fossil fuel sectors, such as coal and natural gas. Industry leaders from these sectors should play an expanded role in developing future energy strategies for the Commonwealth that incorporate new and existing renewable and energy efficiency technologies.

the Midwest. In Kentucky, about three-fifths of the coal supply is used for electricity generation, and most of the remainder is used in industrial plants.

Coal-fired power plants typically account for more than 90% of the electricity produced within Kentucky, making it one of the most coal-dependent states in the nation. Several hydroelectric power plants account for most of the State's remaining electricity generation. Kentucky is the fifth largest hydroelectric power producer east of the Mississippi River [4].

In 2007, the Governor's Office of Energy Policy commissioned a study completed by the Kentucky Pollution Prevention Center to find the potential for energy savings in Kentucky. The study, entitled "An Overview of Kentucky's Energy Consumption and Energy Efficiency Potential" (http://louisville.edu/kppc/news1/2007-kentucky-e2-potential-study.html) found significant opportunities for energy savings and detailed the state's current and projected energy use to 2017 in the following sectors.

Residential Sector

The residential sector consumed nearly 354 tBtu of energy in 2003 at a cost of $2.2 billion (2003 dollars). Electricity and natural gas comprised the majority of delivered energy at 51% and 38%, respectively (excluding electricity related losses). The primary end use for energy was space heating (42%), followed by lighting and miscellaneous equipment (32%). From 2008 to 2017, residential consumption is expected to increase 7.8% to 458 tBtu.

Commercial Sector

The commercial sector consumed nearly 249 tBtu of energy in 2003, while total expenditures were approximately $1.4 billion. Electricity (54%) and natural gas (35%) were the dominant forms of delivered energy. Energy use for space heating (17%) and lighting (12%) was significant, however half of the energy was attributed to the "all other" category.

Energy consumption in Kentucky's commercial sector is expected to grow 22% between 2008 and 2017 – three times the increase predicted for the residential sector. Without changes, consumption is predicted to reach 382 tBtu in 2017 due, in part, to an increase in the use of electrical equipment.

Industrial Sector

Kentucky's industrial sector consumed nearly 830 tBtu of energy in 2003 at a cost of approximately $3.2 billion. Petroleum (36%), electricity (30%) and natural gas (21%) were the main forms of delivered energy consumed by the industrial sector. One-half of all electricity was used by motors; 17% was used for process heating applications. The vast majority of natural gas is used in process heating (54%) and boilers (36%). Energy consumption in the industrial sector is expected to reach 989 tBtu in 2017, a 6.5% increase over the forecast for 2008.

Transportation Sector

Kentucky's 2005 energy use for transportation was estimated to be 53,898 thousand barrels of motor gasoline, 32,777 thousand barrels of distillate fuels and 7,105 thousand barrels of jet fuel[5]. Transportation energy use represents a significant portion of total energy use for the state. Petroleum consumption has grown from 843,000 gallons a day in 2000, to 1,016,000 gallons a day in 2007.

[2, 3, 4] Energy Information Administration (EIA). http://tonto.eia.doe.gov/state/state_energy_profiles.

[5] U.S. Energy Information Administration. http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=KY

Kentucky's Projected Energy Use in 2025

Energy consumption in Kentucky has dramatically increased since 1960, and the trend toward increased consumption is expected to continue. Figures 2a and 2b from "Kentucky Resources to Meet the Energy Needs of the 25x'25 Initiative," show the Energy Information Administration's Annual Energy Outlook (AEO) for energy used in Kentucky in 2005 by sector.

"Site energy" is the energy measured at the point-of-use by the consumer and does not take into account the losses that occur in generation and transmission of energy. "Source energy" is the energy content of the primary fuel and is a measure of energy before transmission and generation losses.

Figures 3a and 3b show the Energy Information Administration's Annual Energy Outlook (AEO) predictions of energy usage in Kentucky in 2025 by sector.

In 2025, Kentucky's total site energy usage is projected to grow from 1.301 quad (a quad is a quadrillion, or 1,000 trillion btu) per year to 1.603 quad per year, an increase of over 23%. The transportation and industrial sectors are predicted to experience the largest growth in energy usage.

Working cooperatively with all energy producers, consumers, and stakeholders is key in developing comprehensive energy strategies that have the best chance for success in a real world economy.

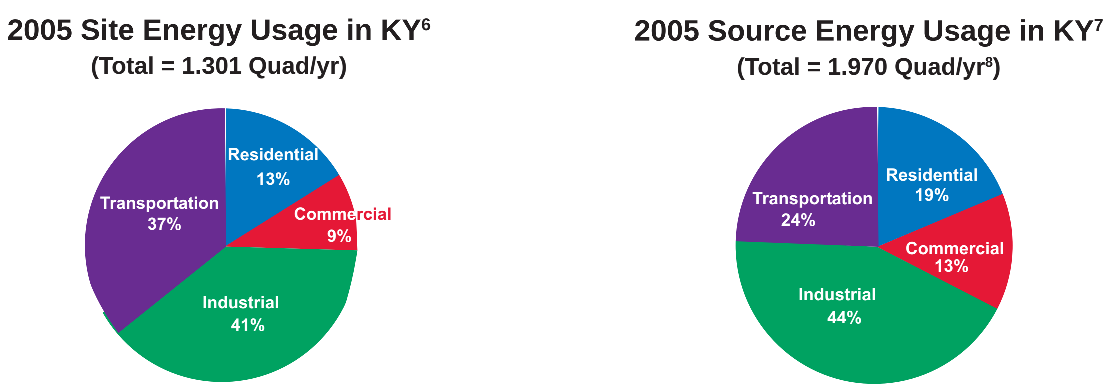


Figure 2a and 2b. 2005 Distribution of Site and Source Energy Usage by Sector in KY

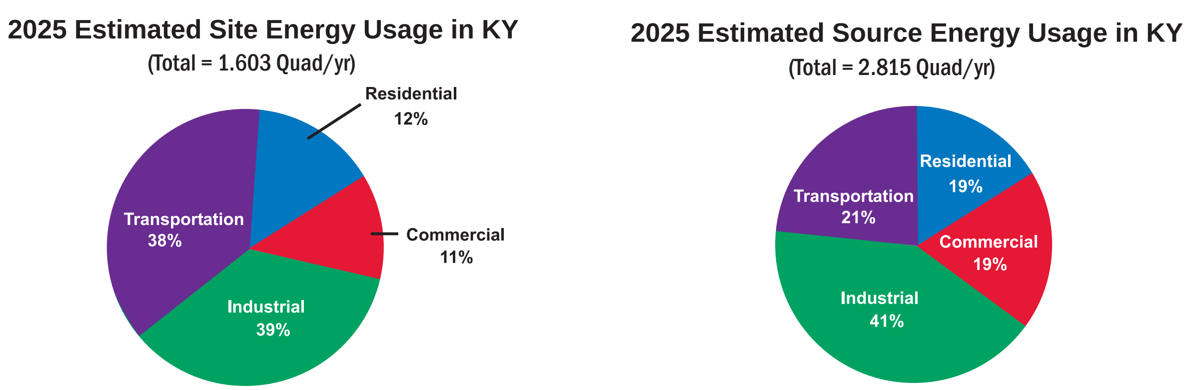


Figure 3a and 3b. Distribution of Predicted 2025 Site and Source Energy Usage by Sector

[6] Site energy from Net Energy column in Tables S4, S5, S6, and S7 of http://www.eia.doe.gov/emeu/states/_seds.html

[7] Source energy from http://www.eia.doe.gov/emeu/states/sep_sum/html/pdf/sum_btu_1.pdf

[8] One Quad/yr is 1,000 trillion (1,000,000,000,000,000 or 10^{15}) btu/yr

Kentucky has an abundance of natural resources that could sustain bioenergy production at an economically viable level. Coupled with Kentucky's rich natural resources, there is a long and successful agricultural tradition in the state.

In traditional farming, Kentucky ranked:

- **14th for corn,**
- **14th for soybeans,**
- **19th for all wheat for grain,**
- **12th for grain sorghum,**
- **1st for burley tobacco, dark fire tobacco, dark air tobacco,**
- **25th for alfalfa hay,**
- **3rd for all other hay, and**
- **18th for barley for grain in national rankings.**

To meet the goal of harvesting 25% of Kentucky's energy from efficiency measures and renewable sources, the state's natural resource base must be robust enough to develop and sustain bioenergy production at an economically viable level. The state has an abundance of natural resources that could sustain bioenergy production and create new economic opportunities for its rural communities.

The following information is from the Kentucky Landscape Census project (http://klc.ky.gov/) funded by the National Aeronautics and Space Administration (NASA).

The most prevalent landcover class in the state is deciduous forest which comprises 47 percent or approximately 12 million acres. If evergreen and mixed forest are added to the deciduous forest class, the total acres of the state covered by forest is 13.2 million acres or 51%. Figure 4 shows the forested class which was identified in the Kentucky Landscape Snapshot project.

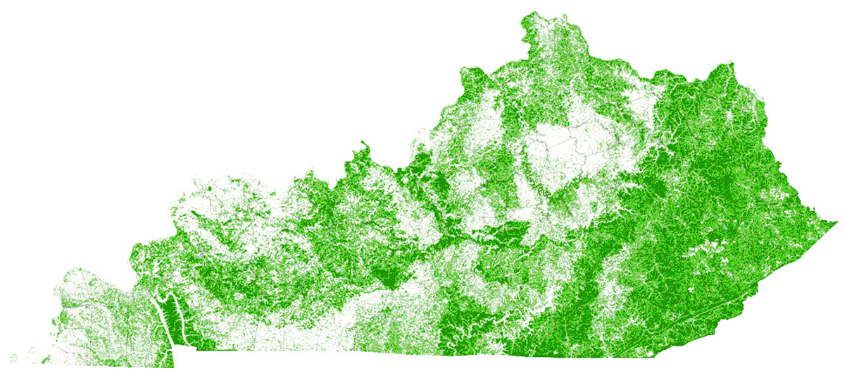


Figure 4. Forested class. Satellite imagery showing tree canopy.

After deciduous forest, the next most prevalent landcover in Kentucky is pasture and hay (Figure 5). This class has 5.6 million acres in the state and is 21 percent of the total landcover. The large majority of the pasture/hay land occurs in the central part of the state with very dense pasture/hay showing up in the Bluegrass Region.

Areas of grasses, legumes, or grass-legume mixtures are planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay accounts for more than 20 percent of total vegetation.

The third most prevalent landcover is cultivated crops (Figure 6). A total of 2.8 million acres, or 10 percent of the land in the state, falls into the cultivated crops class. The majority of cultivated croplands occur in the western portion of the state and are used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, as well as perennial woody crops such as orchards and vineyards. Crop vegetation accounts for more than 20 percent of total vegetation and includes all land being actively tilled.

As the maps indicate, there is a large percentage of acreage in the state that is currently not under cultivation but may be suitable for energy crops that will not compete with food production. Where the wooded wetlands and emergent herbaceous classes are located, there are other possibilities for sustainably grown energy crops that are tolerant of hydric soils and that flourish in wet conditions.

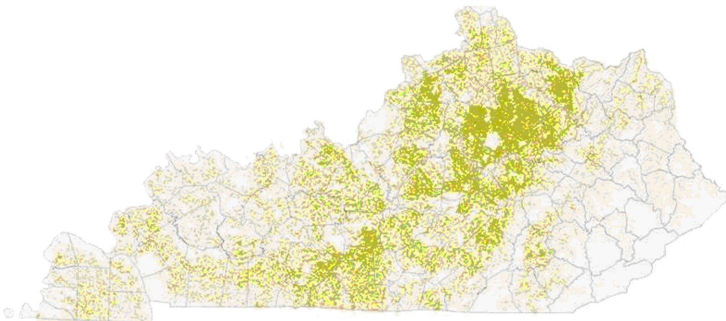


Figure 5. Pasture/Hay.
Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.

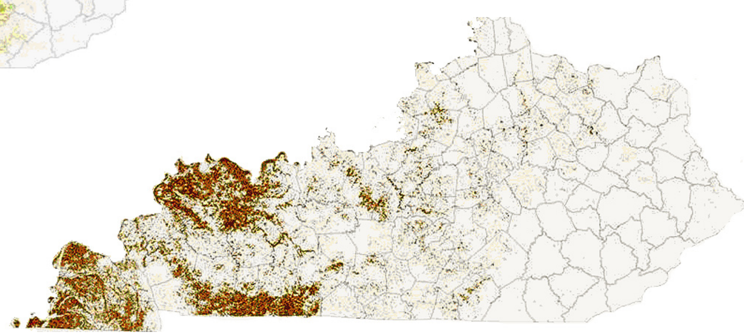


Figure 6. Cultivated Crops.
Areas used for the production of annual crops.

Energy efficiency is the fastest, cheapest, and cleanest source of "new" energy. It can help reduce the strain on existing energy infrastructure and offers new solutions to help slow the growth of energy demand.

Kentucky has the necessary natural resources, agricultural expertise and potential for energy efficiency savings to achieve the goal of having 25% of Kentucky's energy come from efficiency measures and renewable sources. In order to reach this goal, Kentucky must identify and begin to act on opportunities that exist now, and plan for future opportunities as they become available through emerging technologies and ongoing research efforts.

The following section of the Roadmap will discuss the potential for energy efficiency savings and renewable energy production within the Commonwealth. Detailed analysis of these potential goals are examined in section four (Kentucky Resources to Meet the Energy Needs of the 25x'25 Initiative) of this report.

Energy Efficiency and Demand Reduction

The key element in meeting the Kentucky 25x'25 goal is energy efficiency. Energy efficiency is the fastest, cheapest, and cleanest source of "new" energy. It is vital to the Commonwealth's future that actions are taken now to adopt energy efficiency technologies and slow the growth of energy demand.

Kentucky households could reduce site energy consumption by 30.9 trillion btu (tbtu) in 2025. Residential energy consumption in 2025 would be 172.6 tBtu, if the housing stock operated at 2007 levels of efficiency and there were no improvements in energy efficiency. Energy improvement strategies have the potential to reduce energy consumption in 2025 to 141.7 tBtu.

University of Kentucky College of Agriculture: *Kentucky Resources to Meet the Energy Needs of the 25x'25 Initiative*

A 2007 report for the Kentucky Governor's Office of Energy Policy, produced by the Kentucky Pollution Prevention Center, University of Louisville, entitled "An Overview of Kentucky's Energy Consumption and Energy Efficiency Potential," found that there is significant opportunity and value for energy efficiency in Kentucky. Improved energy efficiency could meet all of the growth in energy demand predicted by 2017. Under the moderately aggressive scenario, energy consumption in 2017 would be less than in 2008 by 30 trillion British thermal units (tBtu). The annual energy savings would represent more energy than 300,000 households use each year. Over the 10-year period, the cumulative potential from improved energy efficiency would save Kentucky 449 tBtu and $6.8 billion. This amount of energy is equivalent to the power that three 500-megawatt power plants would generate over a 10-year period.

The study examined residential, commercial and industrial sectors to determine the potential for energy savings. Results from the report suggest that the residential, commercial and industrial sectors in Kentucky have the potential to achieve significant cost savings by implementing energy efficiency practices. Conservative estimates for implementing energy efficiency measures indicate that by 2017 Kentucky could save the following:

- Residential Sector - $459 million in savings
- Commercial Sector - $211 million in savings
- Industrial Sector - $3 billion in savings

Further advancements in energy efficiency technologies could result in greater savings by 2025. In 2003, Kentucky was fortunate to have one of the lowest combined utility rate structures and the lowest electricity rates in the nation. According to Kentucky's Comprehensive Energy Strategy Report, these low rates encourage "… energy-intensive practices, policies and procedures." Clearly, energy efficiency opportunities exist within the state. Significant improvements in energy efficiency can be achieved by implementing currently available and cost-effective technologies.

Section four of this report, "Kentucky Resources to Meet the Energy Needs of the 25x'25 Initiative," details energy efficiency potential for Kentucky in residential, commercial and transportation sectors. The following is a summary of these findings.

Kentucky Residential Sector
2025 Source Energy Savings Potential

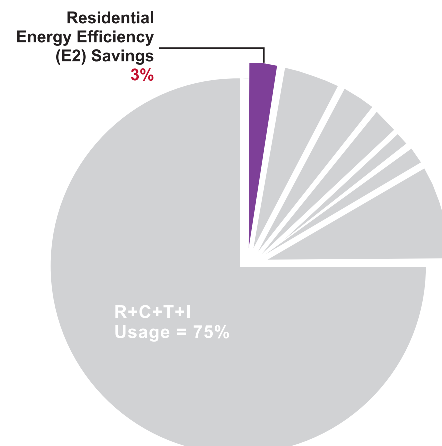
70.7 trillion Btu

(5,524,000 megawatt-hours electricity)
(11,680,000 thousand cubic feet natural gas)
$703,130,000
17.9% reduction

Figure 7. 2025 Source Energy Savings Potential

Residential Energy Efficiency

The energy efficiency potential of residential housing is considered in three areas: base case, which considers policies that encourage purchasing more efficient appliances and HVAC when equipment is replaced; improvements made to existing houses, and; improvements made in new housing construction. Base case projections are relatively flat, while existing housing and new construction represent more aggressive targeted programs for energy efficiency. For the existing housing stock, base case energy consumption per household is assumed to mirror the average for the East South Central Region from the 2001 EIA Residential Energy Consumption Survey and will decrease 0.5% per year through 2025. The energy consumption for new construction in 2008 is derived from a typical Kentucky house that just meets the 2006 International Residential Code, also decreasing 0.5% per year through 2025.



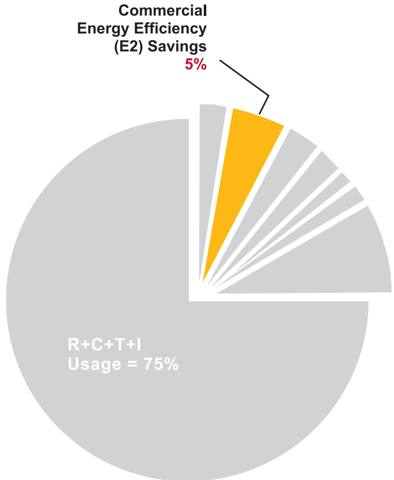
Improvements to existing housing units assume that between 2008 and 2025 one-half of the existing housing stock (52,489 households per year) will implement energy efficiency measures sufficient to reduce their Base Case energy consumption by 20%. Examples of these types of measures include better air sealing, added insulation and/or improved HVAC systems.

Improvements to new housing construction assume that a growing portion of new housing starts will consume 15% less energy than their peers. This is equivalent to today's criteria for ENERGY STAR certification. It is assumed that the adoption rate of these new energy efficient houses increases by 2.8% per year which results in one-half of all new housing starts in 2025 exceeding new base case performance by 15%. As shown in figure 7, Kentucky's residential sector could reduce consumption by 70.7 trillion Btu by 2025.

Commercial Buildings Energy Efficiency

The energy efficiency potential of commercial buildings in Kentucky was examined in four different strategy options. Figure 8 illustrates the results of applying the different options to commercial building's Energy Use Intensity (EUI).

Option 0 (Base Case) : EIA Projected Increase in EUI - The EIA Annual Energy Outlook EUI long-term projections for the commercial sector increased over time due to the projected increase in use of electronic equipment despite anticipated improved efficiencies in equipment.



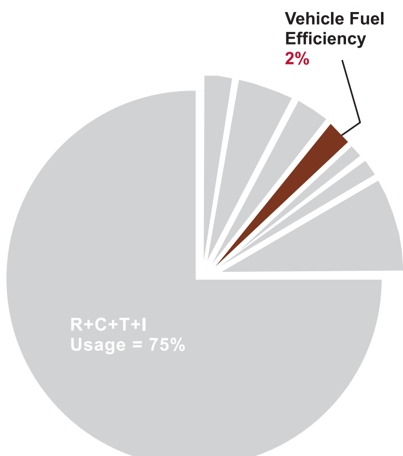
Option 1: EUI remain constant over time – This option assumes that any increases in equipment are off-set by improved efficiencies in all equipment and new buildings will have the same EUI as existing buildings.

Option 2: EUI for 90.1 code – This option assumes that existing buildings will have the same EUI as they currently have and all new buildings will be built and operate at the energy levels given in Standard 90.1-2004 – the basis for the commercial model energy codes.

Option 3: EUI decreased by 30% every five years on new buildings – This option assumes that existing buildings will have the same EUI as they had in 2004 and all new buildings will be built and operated at the energy levels given in Standard 90.1; and the levels given in Standard 90.1 are reduced by 30% in 2010 and a further 30% reduction every five years thereafter. This option is roughly based upon the Zero Energy Building by 2025 goals of the USDOE, ASHRAE, AIA, and Architecture 2030 and the mandate given for federal buildings in the 2007 Energy Act. A detailed look at commercial building energy efficiencies is in section four of the Roadmap report.

	2025 Usage (Site Energy)	Savings from Base Case (tbtu/yr)	
		Site Energy	Source Energy
Base Case - Assumed EUI increased as per AEO	117.7		
Option 1 - Assumed Constant EUI	97.5	20.2	62.3
Option 2 – Assumed New Buildings have 90.1 code usage	84.1	33.6	103.8
Option 3 – Assume New Buildings built to advanced code	70.4	47.3	146.0

Figure 8. Total Energy Usage - Commercial Sector with Different Energy Savings Options, (tbtu/yr)



Transportation Energy Efficiency

Kentucky's transportation energy use is significant. In 2005, Kentucky consumed 133,524,000 barrels of petroleum[9]. The Federal 2007 Energy Independence and Security Act requires the Department of Transportation to set tougher fuel economy standards, starting with model year 2011, until the standards achieve a combined average fuel economy for model year 2020 of at least 35 miles per gallon (mpg). The standards apply to the total fleet of passenger and non-passenger automobiles manufactured for sale in the United States for that model year, up to a gross vehicle weight of 10,000 pounds. Currently, passenger automobiles must achieve an average of 27.5 mpg, while "light trucks"—a category that includes pickup trucks, sport utility vehicles, and minivans—must achieve 22.5 mpg, bringing the average for cars and light trucks to about 25 mpg.

The effect of this increase in transportation energy efficiency will be significant. It is estimated that 62 tBtu could be saved in 2025 if we improve the fuel economy of light duty vehicles from 28.9 mpg (the projection used in 2006 AEO) to 35.0 mpg (the requirement of the 2007 Energy Independence and Security Act).

[9] U.S. Energy Information Administration. http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=KY

Industrial Energy Efficiency

The energy efficiency potential at a typical industrial facility in the U.S. is in excess of 10%. With the Commonwealth's high ranking for energy intensive use, Kentucky's industries should have a higher than average potential for energy efficiency savings.

For demand reduction, or any energy efficiency program, to become widely promoted by the host utility, it must be designed to minimize utility financial concerns. Utilities have three major areas of concern for energy efficiency programs: 1) assuring cost recovery for the direct costs of the program; 2) addressing the disincentive of reduced income associated with reduced energy consumption; and 3) providing an opportunity for shareholder earnings to be based on good performance of energy efficiency programs.

Cost recovery can be accomplished by embedding costs in rates as part of a utility's resource procurement budget, through special tariff riders, or through public purpose surcharges (e.g. "system benefits" charges). Lost sales can be addressed by separating – or decoupling – the utility's cost recovery mechanism, which includes a return on investment, from the actual volume of energy sold. Shareholder incentives can be developed to provide utilities with direct rewards for reaching designated targets, or to allow utilities to earn an equal or higher rate of return on energy efficiency investments [10].

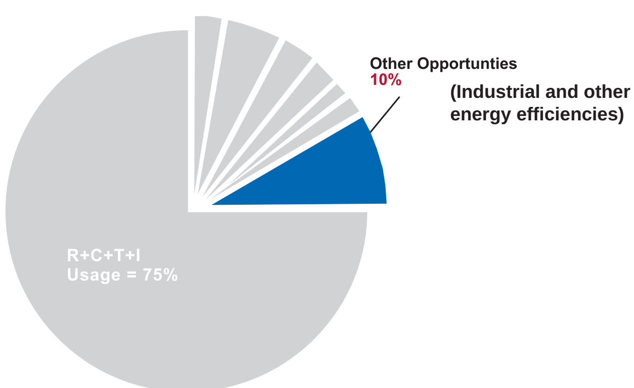
Rate changes may reduce industrial peak period demand by 6% to 12% if peak period rates are calculated to reflect the higher cost of power during such periods. Rate changes could defer the need for utility providers to construct additional capacity in Kentucky for one or more years [11].

Estimates from the GOEP/KPPC publication "An Overview of Kentucky's Energy Consumption and Energy Efficiency Potential," show industrial energy savings potentials for electricity and natural gas. The study sets out a minimally aggressive scenario that could save $1.7 billion in electricity by 2017 and $1.3 billion in natural gas for industrial consumers.

Potential areas for improvement in Industrial Energy Efficiency include:

- purchase of energy-efficient equipment;
- lighting improvements, including controls and daylighting;
- motor management — (one of the most efficient, practical technologies) motor rebuilding versus replacement;
- optimal tuning of manufacturing equipment;
- energy balancing, such as waste heat recovery, and;
- proper examination of energy use, energy costs, and savings opportunities.

National Action Plan for Energy Efficiency Vision for 2025: *Developing a Framework for Change*



[10] ACEEE Report: *Aligning Utility Interests with Energy Efficiency Objectives: A review of recent Efforts at Decoupling and Performance Incentives, October 2006)*

[11] LaCapra Assoc Study: *Report on Rate Design and Ratemaking Alternatives as they Impact Energy Efficiency, Nov 21, 2007*

Potential Ethanol and Biodiesel Produced in Kentucky from Biomass Fuels		
	Million Gal/yr	tBtu/yr
Corn	186	14.1
Switchgrass	361	27.4
Corn Stover + Residues	121	9.2
Vegetable Oil to Biodiesel	107	14.9
Total	775	65.6

Figure 9. Potential biomass fuel production

Renewable Energy Production

The USDA predicts a strong future market for renewable energy. The availability of ethanol and biodiesel at the fuel pump is becoming more prevalent. Rising fuel prices, environmental concerns, pressures for oil independence, and Federal energy policy are creating a strong market for renewable energy.

Bioenergy is renewable energy derived from biological sources, to be used for heat, electricity, or vehicle fuel. Biofuel derived from plant materials is among the most rapidly growing renewable energy technologies. In the United States, corn-based ethanol is currently the largest source of biofuel as a gasoline substitute or additive, and recent energy legislation mandates further growth of both corn-based and advanced biofuels from other sources [12].

As fuel costs reach record highs (on June 11, 2008, the national average for regular unleaded was $4.05), the market for renewable energy will continue to grow and the cost per gallon of biofuel will become increasingly competitive with or even lower than fossil fuel.

During 2004, Kentucky's gasoline consumption was 2,320 million gallons per year. Based on ethanol's energy content (70% of the energy content of gasoline) the state could replace up to 21% of its 2004 gasoline consumption, or 255 million gallons per year, by using its current land resources to produce ethanol. On an annual basis, ethanol production could add up to $355 million to the state's economy and create as many as 2,244 new permanent jobs. Tax revenue would increase by $3.1 million per year and construction of plants to produce this volume of ethanol would result in $486 million dollars of value-added benefits in Kentucky [13].

Displacing 21% of Kentucky's petroleum consumption with renewable biofuels will require that a number of strategies and production techniques be put in place. Figure 9 illustrates the potential volume of ethanol and biodiesel production from a variety of biomass sources in the Commonwealth and the potential total energy savings in tBtus.

Ethanol from Corn

Corn makes a good feedstock for ethanol production because of the large amount of starch present in the plant. Starch can be easily broken down into simple sugars (glucose), which can then be fed to yeast in the fermentation process to produce ethanol. Commercial techniques can produce approximately 2.7 gallons of fuel-grade ethanol per bushel of corn. The process also produces animal feed as a by-product.

Kentucky produced approximately 1.4% of the nation's total corn crop over the past five years [14]. In 2006, 5.4 billion gallons of ethanol were produced in the U.S. Assuming Kentucky would produce 1.4% of the ethanol, approximately 63 million gallons of ethanol per year could be produced from 32 mil-

[12] U.S. Department of Agriculture at http://www.ers.usda.gov/features/Bioenergy/

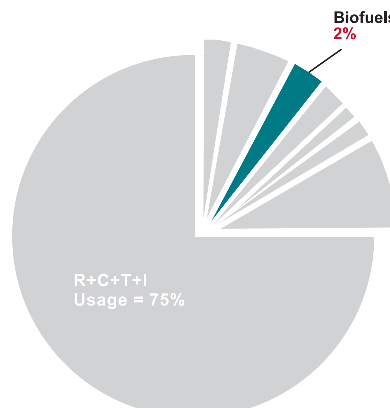
[13] Kentucky Resources to Meet the Energy Needs of the 25x'25 Initiative. University of Kentucky, College of Agriculture, Research manuscript Number 08-05-038, revised 7-24-08

[14] USDA National Agricultural Statistics Service – http://www.nass.usda.gov

lion bushels of corn. As demand for corn used for ethanol increases, so to would corn production levels from fallow ground, hay ground, and other row crops. To meet expected demand, an estimate of an additional 44 million bushels of corn grown per year would bring the total ethanol production figure to 186 million gallons per year for the state.

Corn production is at the center of the current debate over "food vs. fuel." This debate will likely continue as fuel prices climb and the demand for biofuels continues to grow. A recently released publication from the U.S. Department of Energy (DOE) entitled "DOE Committed to Environmentally Sound Biofuel Development" (www1.eere.energy.gov/biomass/news_detail.html?news_id=11794) addressed some of the recent land use and biofuel carbon debt studies which predict a negative impact on forest and crop land for food production, and an increase in greenhouse gases. The DOE states that two of the studies are "…plagued by incorrect or unrealistic assumptions and obsolete data." According to the DOE, land resources in the U.S. can provide more than 1.3 billion dry tons annually and still continue to meet food, feed, and export demands (USDA baseline).

Ethanol from Switchgrass and Crop Residues



Lignocellulosic materials such as switchgrass and crop residues hold great promise for future biofuel production. The potential for Kentucky lies in using crop residues and "other-hay" – hay other than alfalfa. Kentucky currently has 2.15 million acres of land in other-hay with an annual yield of 2.3 tons per acre. Kentucky has a significant source of land available for renewable energy production in other-hay crop land. Assuming that switchgrass could be sold at the same price as hay, 25% of the other-hay land could be converted to switchgrass resulting in a higher income per acre for farmers since the expected yield would be 6 tons per acre. If this 25% conversion took place, 4.5 million tons per year of switchgrass would be available for ethanol production. This scenario could produce 361 million gallons per year of ethanol from switchgrass alone.

Other crop residues such as corn stover and wheat straw could also be used to produce ethanol. Kentucky's corn and wheat production levels could supply an additional 1.5 million tons per year of residue material with an average ethanol yield of 80 gallons per ton. The total from cellulosic crops would be 121 million gallons per year.

Biodiesel from Oilseeds

Biodiesel is produced from any fat or oil such as soybean or canola oil, through a refinery process called transesterification. This process is a reaction of the oil with an alcohol to remove the glycerin, which is a by-product of production. Fuel-grade biodiesel must be produced to strict industry specifications (ASTM D6751). Biodiesel does not contain petroleum, but can be blended at various levels with petroleum diesel to create a biodiesel blend.

Using 25% of Kentucky's current soybean production for biodiesel could displace 1.35% of diesel fuel consumption per year. If 25% of the soybean crop and 25% of the wheat crop were converted to a canola/sunflower double crop rotation, 8.1% of the diesel fuel consumed could be displaced. Development of new cropping systems (canola, algae, etc.) will be required in order to have any significant impact on distillate fuel consumption in Kentucky.

Biofuels Summary

If Kentucky uses a portion of its corn, corn stover, wheat straw, switchgrass, and vegetable oil production for biofuel production, the total potential is 775 million

Renewable energy can provide important benefits to the State as well as local communities. The key benefits are:

- **Environmental** – Most renewable energy technologies are clean sources of energy that can have a much lower environmental impact than conventional energy technologies.
- **Sustainability** – Renewable energy by definition is replenishable. Other sources of energy are finite and will someday be depleted or become too expensive to use.
- **Economic** – Most renewable energy investments, unlike investments on costly imports, are usually made within the state – frequently in the same region or town as the users of energy. The result is that energy dollars stay home to create jobs and fuel local economies, rather than going overseas. Kentucky farmers may find additional benefits to renewable energy in the form of production of crops for processing into biomass fuels and land leases for the production of wind energy.
- **Security** – Our national dependence on foreign oil supplies leaves us vulnerable to supply disruptions and price fluctuations and complicates our foreign relations.
- **Price Stability** - Smart investors typically acquire a portfolio of stocks and bonds to reduce risk. Including renewables as part of Kentucky's power supply portfolio would do the same by protecting consumers from fossil fuel price shocks and supply shortages. During the 2002-2003 winter, natural gas prices surged to record highs across the country – in some places tripling. Renewable energy producers, in contrast, are not subject to commodity price spikes.

gallons of biofuel per year. This is a significant amount of energy that has the potential to add up to 65.6 trillion Btus per year to Kentucky's energy mix, while reducing our reliance on foreign energy sources.

Alternative Energy Technologies

In addition to energy efficiency measures and biofuel production, using alternative energy sources can have an impact on the total energy consumed in the Commonwealth. The following sources are summarized from section four of the Roadmap.

Solar Water Heaters

Installing a solar water heater can save energy, lower costs and reduce the amount of C02 produced. There are two popular sizes of solar water heaters which are typically installed in a residence or business, a 32 square foot and a 64 square foot model. As an example, installing a 64 square foot heater on 20% of the new homes built in Kentucky between now and 2025 (77,638) would save approximately 0.625 trillion Btus per year.

Using the 20% example, solar water heating could reduce C02 by 0.21 million metric tons per year. An estimated 840 new jobs would be created for installers and retail sales of solar water heaters based upon the 20% market penetration figure.

Solar Photovoltaics

Photovoltaics (PV) is a technology that converts light directly into electricity using solar cells or a photovoltaic array. With a growing demand for solar energy, the manufacture of solar devices has increased dramatically in recent years. Production of photovoltaics jumped to 3,800 megawatts worldwide in 2007, up an estimated 50 percent over 2006. At the end of the year, according to preliminary data, cumulative global production stood at 12,400 megawatts, enough to power 2.4 million U.S. homes[15].

The amount of energy saved by installing a solar photovoltaic (PV) system on new houses in Kentucky ranges from approximately 1.3 to 3.8 trillion Btu per year. The range of savings is based upon the number of PV systems installed: 10-, 20-, or 30% of the estimated 388,191 new homes built between 2008 and 2025. This represents 38,819, 77,638, and 116,457 houses respectively for the 10-, 20- and 30% market penetration.

In addition to energy savings, PV technology could create 1,075 new jobs (at 20% market penetration), reduce peak electricity demand when connected to the grid, and reduce C02 by approximately 0.10 to 0.31 million metric tons per year.

Wind Energy

While Kentucky has relatively low wind energy potential compared to other parts of the nation, there are certain areas of the state that may benefit from smaller distributed wind systems. Most of the state is classified as class 1 or class 2

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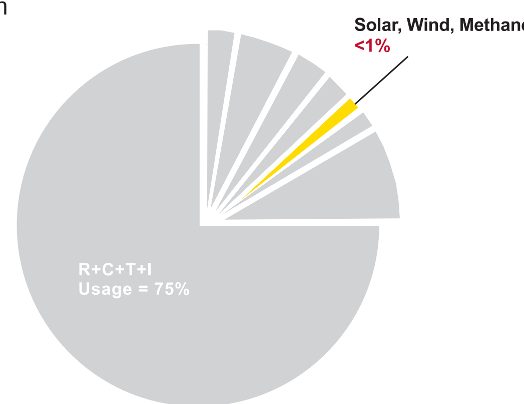
[15] Earth Policy Institute at http://www.earth-policy.org/Indicators/Solar/2007.htm

wind power designation, with small areas of class 3 along the mountain ridges in the extreme southwestern part of the state. Wind turbines require class 3 or better to operate efficiently. Class 2 is considered marginal and class 1 unsuitable. The American Wind Energy Association estimates that Kentucky has 49 square kilometers of class 3 or better areas, which if developed, could produce 34 megawatts of wind energy power on average. The annual source energy from this potential wind power would be about 1.0 trillion Btu per year.



Methane from Landfills

Methane (CH_4) is a greenhouse gas that remains in the atmosphere for approximately 9-15 years. Methane is over 20 times more effective in trapping heat in the atmosphere than carbon dioxide (CO_2) over a 100-year period and is emitted from a variety of natural and human-influenced sources. Human-influenced sources include landfills, natural gas and petroleum systems, agricultural activities, coal mining, stationary and mobile combustion, wastewater treatment, and certain industrial process.

Methane is also a primary constituent of natural gas and an important energy source. As a result, efforts to prevent or utilize methane emissions can provide significant energy, economic and environmental benefits[16]. The Environmental Protection Agency (EPA) maintains a database of landfill gas energy projects and candidate landfills. According to the EPA, Kentucky has 6 active landfill-to-energy sites, 18 candidate sites and 12 sites that could have landfill-energy potential.

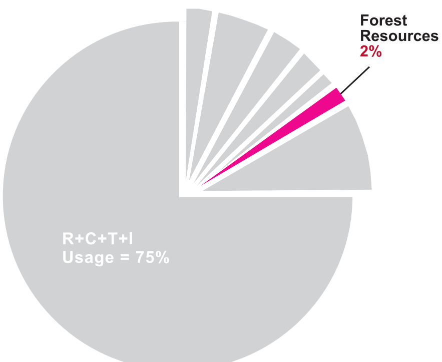
Of the six active landfill sites, five are used to generate electricity having a combined 16 megawatts of production capacity. The sixth, by far the largest landfill site in the state, provides 0.72 million cubic feet of gas per day to an industrial park for use in steam boilers – approximately half of the methane collected at the landfill. The 18 candidate and 12 potential sites have a total of 53.4 million tons of waste in place.

Assuming that all of the methane at the largest landfill can be utilized and that the waste available for energy projects in the future will approximate the tonnage held currently, landfill methane recovery could provide 2.0 trillion Btu of source energy in 2025. The following table from section four of the Roadmap assumes methane contains 506 btu/ft^3 and that 1 million tons of waste in place is equivalent to 0.8 MW of electricity generating capacity.

Figure 10. Landfill Energy Potential (source energy, tBtu/yr)

Landfill Sites	Utilization	2008	2025
5 active	Electricity	0.48 (16 MW)	0.48 (16 MW)
1 active	Direct	0.13 (0.72 million scfd)	0.27 (1.4 million scfd)
18 candidate + 12 potential	Electricity	0	1.3 (42.7 MW)
Total Site		0.6	2.0
Total Source		1.7	5.9

[16]U.S. Environemental Protection Agency at http://epa.gov/methane/



Biopower from Forest Resources

Kentucky has one of the most diverse hardwood species mix in the nation with about 12 million acres of forestland. The Commonwealth is 47 percent forested. Eighty-nine percent of Kentucky's forestland is privately owned. Kentucky's timber Industry generates more than $4.5 billion of revenue annually from the primary and secondary wood industries. There are more than 3,500 forest industries in the state. These industries employ more than 30,000 Kentuckians[17].

Kentucky ranks second nationally in hardwood production and has a large potential for producing woody material for renewable energy. Antares Group has estimated a potential of 1.21 and 1.95 million dry tons per year from forest thinnings and forest residues respectively. They also estimated a potential short rotation woody crop (such as hybrid poplar or willow) production of 3.78 million tons/yr from 25% of the land not cropped or enrolled in CRP (Conservation Reserve Program). Short rotation woody crops are estimated to have a biomass yield of 4.5 dry tons/ac/yr. Therefore, the total potential woody material would be 6.94 million dry tons per year. Assuming an energy content of 8,000 btu/dry lb and 25% of the woody material identified would be collected; the woody material would produce 66.9 trillion btu of source energy per year.

In addition to its renewable energy potential, using forest resources to generate electricty can displace CO_2. A study by Gan and Smith (2006)[18] estimated that about 40 million dry tons of logging residues could be recovered annually in the U.S. If this biomass were used for electricity production, the amount of carbon displaced would reach 19.4 million tons C. This is equal to approximately 3% of total current carbon emissions from the U.S. electricity sector.

Algae Biodiesel [19]

There is a considerable body of literature on the potential of growing algae for the production of biofuels. Algae-to-biofuel production plants are already operating in Texas, Hawaii and California, however "algae" encompass a large diversity of organisms that occupy all aquatic ecosystems from marine to freshwater. Much research remains to be done to identify the best algal species to use for this purpose. In Kentucky the ideal species must be a common freshwater algae that is already abundant and grows well under local conditions. Most likely it will be a species of diatom. Diatoms store photosynthetic energy as oils. They grow as dominant algae in the Ohio River and in most farm ponds in the state. The Northern Kentucky University's Diatom Herbarium has recently started a feasibility study on this topic and is compiling a searchable database of literature and current practices related to the use of algae for biofuel production. So far, most of the literature shows the current use of "green algae" (Chlorophyta) such as Botryococcus or Chlorella that, like higher plants, have cellulose cell walls and store their "food" as starch. Other work involves marine algae. There is no work so far on the potential of freshwater diatoms for producing biodiesel. Housed at the NKU Diatom Herbarium are over 1,700 preserved diatom species and a database compiled over 30 years cataloging the essential environmental conditions required for a wide array of diatoms to grow.

Using diatoms for Biodiesel production will have highly desirable environmental consequences: they use carbon dioxide (a green-house gas) from the atmosphere

[17] Kentucky Division of Forestry at http://www.forestry.ky.gov/forestfacts/

[18] Gan, J.; Smith, C.T.. 2006. Availability of logging residues and potential for electricity production and carbon displacement in the U.S.. Biomass and Bioenergy. 30(12): 1011-1020

[19] *Algae's Potential for Biofuel Production in Kentucky*, Miriam Steinitz-Kannan, Regents Professor, Northern Kentucky University

to produce their oil. Many species can grow on sewage or farm waste, removing nutrients such as Nitrates and Phosphates from the waste-water. This reduces the need for costly water treatment and results in reduced pollution of our rivers and streams. Many diatom species grow attached to substrates, which can make them easier and less costly to harvest. Because of their variety of photosynthetic pigments, they are also more efficient than other algae in their use of solar energy and many species can even grow well in the winter. The best species to use for oil production however, must still be identified. Pilot plant studies need to be done to develop a method for growing high oil-yielding diatoms using sewage or agricultural waste water. Finally a method to harvest the algae and transform it into commercially viable biodiesel still needs to be developed.

As we develop our energy strategies and work toward the 25x'25 goal, we must also conserve, protect and maintain our environment. We support new technologies and systems that improve soil, water, and air quality and preserve wildlife habitat as we produce and use biomass energy.

Conclusion

This Roadmap report has focused on developing achievable goals and setting realistic targets for securing Kentucky's energy future. Harnessing Kentucky's extensive resources and ingenuity can provide energy security for our state and nation, create jobs, stimulate economic development, and offer a prudent hedge against volatile energy supplies and prices along with the impending risks of climate change and the likely reality of future "cap and trade" legislation.

One of the key elements of a successful energy strategy for the Commonwealth is the newly established Center for Renewable Energy Research and Environmental Stewardship (CRERES). This center should lead efforts to develop a strategic plan that combines cooperative research efforts from Kentucky's universities, educates the public, industry leaders, and state and local officials about the broad-based benefits of bio-based products, and help create incentives for increasing the number of highly qualified energy and energy efficiency researchers at state universities.

It is vital to Kentucky's energy future that the state become competitive in securing federal grants for research, demonstration and deployment of renewable energy technologies. The Department of Energy has announced more than $1 billion of investment in biofuel research and deployment projects over the past year, which includes ten major cellulosic biofuel demonstration projects (which mostly use waste materials) and three bioenergy centers.

KREC also recognizes the importance of Kentucky's existing fossil fuel industry base and the state's comparative advantages as an industry leader in these important fossil fuel sectors, such as coal and natural gas. Working cooperatively with all energy producers, consumers and stakeholders is key in developing comprehensive energy strategies that have the best chance for success in a real world economy.

As we develop our energy strategies and work toward the 25x'25 goal, we must also conserve, protect and maintain our environment. We should support new technologies and systems that improve soil, water, and air quality and preserve wildlife habitat as we produce and use biomass energy.

Rising to this new energy challenge may be one of the most daunting and exciting prospects the people and policy makers of Kentucky face in our lifetime. The KREC Advisory Board strongly believes that by working together, Kentucky can and will become more energy efficient, and will develop clean, sustainable supplies of energy that will secure its economic future for generations to come.

Section Four - KREC Advisory Board Recommendations

The Kentucky Center for Renewable Energy and Environmental Stewardship (CRERES)

KREC's Advisory Board has unanimously agreed that the most important opportunity for partnership and implementation for the future promotion of renewable energy and energy efficiency efforts in Kentucky lies within the scope of a newly legislated center in House Bill 2.

Recommendation #1 - Center of Excellence

It is vital to Kentucky's energy future that a center of excellence for renewable energy and energy efficiency be established, supported, and held accountable for results. House Bill 2, recently passed by the Kentucky General Assembly, established the **Center for Renewable Energy Research and Environmental Stewardship** (CRERES) and attached it to the Governor's Office of Energy Policy (GOEP). KREC's Advisory Board is encouraged by this legislation and supports the center's mission and goals. The establishment of CRERES should advance the efforts of research, development, demonstration and commercialization of renewable energy, biomass co-products, and energy efficiency technologies and practices that benefit Kentucky. The center should be funded with state funds at an adequate and consistent level to ensure a vital, effective center that produces results. We encourage our state leadership to build upon the success of the KREC model as they develop this important Kentucky center of excellence.

The KREC Advisory Board believes that it is crucial to have representation from Kentucky's rural community on the board of directors, and that important consideration be given to expanding the representation to include the Governor's Office of Agricultural Policy and/or recognized leaders from the state's agricultural community.

The KREC Advisory Board recommends that the Center conduct and facilitate research and educate the public, students, and practitioners about problems and issues related to efficient energy use and renewable energy production. This goal should be accomplished by a coordinated group of researchers, educators, and field professionals using the Land Grant Mission as a model. Additionally, through public-private partnerships, the Center should develop broad-based support across the Commonwealth to strengthen collaborative and outreach initiatives.

The Center should also be charged with supporting research, development, and demonstration for further deployment of technologies and outreach activities using the capabilities of the University of Kentucky's College of Agriculture's Experiment Station and Cooperative Extension Service. The Center should work to build public-private partnerships that support Kentucky's rural communities through the wise use of energy.

Ideally, the Center should use the existing KREC model to serve as a catalyst to identify research, education, and dissemination of funding opportunities in areas related to bio-based renewable energy production and efficient use of energy in buildings and processes. In this way, individuals and organizations that have the good ideas and initiative to develop bio-based products, renewable energy, or energy efficiency will no longer have to "go it alone." The Center can serve as their clearinghouse and networking partner to help bring their ideas to market and profitability.

Recommendation #2- Create incentives for researchers

Create incentives for increasing the number of highly qualified renewable energy and energy efficiency faculty and researchers at state universities.

In 1997 the Kentucky legislature approved a bold plan to reform the state's system of higher education. The goal was to develop a "seamless, integrated system of postsecondary education strategically planned and adequately funded to enhance economic development and quality of life." A key component of this reform was the state's creation of the Research Challenge Trust Fund, a strategic investment in university research designed to create new jobs, generate new economic activity, and provide new opportunities for Kentucky citizens. Commonly known as "Bucks for Brains," the program uses state funds to match private donations, effectively doubling the impact of private investment supporting research in strategically defined areas, and planting the seeds for a better future.

In 1998 Kentucky legislators invested $110 million in general fund appropriations to support Bucks for Brains at the state's research and regional universities. They reinforced that commitment with an additional $120 million in 2000 and another $120 million in 2005. The KREC Advisory Board believes that a portion of further funding should be earmarked through Kentucky's Universities for the hiring of highly qualified renewable energy and energy efficiency faculty and researchers at state universities.

This funding, combined with private support, will enable Kentucky's universities to recruit and retain world-renowned faculty versed in renewable energy to work alongside current outstanding faculty. In return, these scholars will create economic opportunity, enhance the education of our students, and draw international attention to the university with significant breakthroughs. This type of support will greatly help Kentucky's universities bring top scholars and scientists from around the world to Kentucky. Their work, in turn, will attract others to the university and creates internationally-recognized centers of expertise. This investment will be the seed that grows to yield benefits for the state's economy, improve the lives of Kentucky's citizens, and enhance the education of students who will be the future leaders, scientists, and entrepreneurs of our state.

Private donors can match renewable energy and energy efficiency Bucks for Brains funding dollar for dollar, doubling the state's investment and providing incentive for individuals and organizations wishing to invest in Kentucky's universities and the future of Kentucky.

Universities are required to raise private donations to match all of the dollars appropriated by the General Assembly. Investment in research attracts additional funding from federal agencies and other organizations. Economists estimate that each dollar in federal funding for research generates $2.20 for the local and state economies, boosting the total economic impact of the 25x'25 plan. Research programs headed by newly hired faculty also create jobs for skilled workers in areas ranging from laboratory technology and information technology to healthcare and administrative support.

Discoveries made through research translate directly into business opportunities. At the University of Louisville, for instance, "Bucks for Brains" has led to spin-off companies focusing on new treatments for cancer, vaccine development, and diagnostic testing

A renewable energy and energy efficiency Bucks for Brains type program will help Kentucky businesses, consumers, and workers by:

- creating technology-based jobs and expanding Kentucky's knowledge economy;
- helping Kentucky companies improve their effectiveness in competitive markets;
- developing cost effective ways to get products to consumers;
- keeping abreast of new technologies, and;
- providing expertise in emerging fields.

This program will also help Kentucky attract and retain world-class researchers and scholars, many of whom are also teachers. The quality of their work raises the national and international academic profile of the Commonwealth. Leading researchers help bring conferences and scholarly meetings to Kentucky, providing revenue to state and local businesses, giving students the opportunity to interact with leaders in their fields and enhancing Kentucky's international reputation. Students at Kentucky universities will also have firsthand learning experiences from faculty who are the best in the field. Hundreds of undergraduate and graduate students work with existing Bucks for Brains scholars, preparing to become the leaders of tomorrow.

To date this investment has allowed Kentucky Universities to attract and retain some of the nation's top researchers and scholars, almost quadrupling the schools' number of endowed chairs from 25 to 125. To date, these Bucks for Brains faculty have secured more than $144 million in additional federal funding for their research. When applied to the areas of renewable energy and energy efficiency application of this existing program to the areas of renewable energy will have a dramatic effect on Kentucky's ability to achieve its 25x'25 goals.

Recommendation #3- Increase public awareness and education

The KREC 25x'25 Core Team believes that establishing a statewide public awareness and education program is necessary to ensure that the general public, the agriculture community and other stakeholders understand the value of renewable energy and energy efficiency technologies. Using the University of Kentucky Cooperative Extension Service to develop and disseminate curriculum and other educational materials on renewable energy opportunities and energy efficiency savings would be the most effective means of providing information and technical support. Partnering agencies and programs in this effort would include, but not be limited to; 4H, Future Farmers of America (FFA), Kentucky Department of Agriculture, Ag in the Classroom, the National Energy Education Development (NEED) project, and the Kentucky Energy Efficiency Program for Schools (KEEPS).

The University of Kentucky Cooperative Extension Service is the most comprehensive outreach and engagement program of its kind in Kentucky. Their mission, simply stated, is to make a difference in the lives of Kentucky citizens through research-based education. The Agricultural Extension Service also has a major responsibility for protecting the sustainability of rural communities – not only by providing a growing net farm income, but also as a conduit for change. Its key organizations also can provide leadership in identifying problems, developing solutions, and taking actions that will help achieve better economic opportunities, improve environmental stewardship, and enhance the quality of life for all. Healthy and prosperous rural communities are a key factor in sustaining the future of Kentucky agriculture and innovations in agriculture are important to the future of rural communities. It may be difficult to convince rural citizens to implement renewable energy and energy efficiency technologies if they don't understand how they can directly benefit.

Currently, the Kentucky Cooperative Extension Service reaches millions of Kentucky residents each year with educational programs in agriculture and natural resources, family and consumer sciences, 4-H and youth development, and community and economic development. We serve as the local "front door" to the campus of the University of Kentucky through local agents working in each of the Commonwealth's 120 county Cooperative Extension offices.

Cooperative Extension has a long history of success working with other community stakeholders that dates to 1914 when county, state, and federal governments agreed that by joining together they could provide all citizens with access to the wealth of knowledge generated by public universities. Today this partnership continues to include county governments working to solve local problems, a national network of land-grant universities including UK and KSU, and the U.S. Department of Agriculture. County agents serve as the link between people in every county, and specialists, faculty, and experts on the Lexington campus at the University of Kentucky and with faculty and staff located at our Western Kentucky Research and Education Center and Quicksand/Robinson Station Research and Education Center. County agents coordinate and provide educational programs for the public through meetings and workshops, field days, personal consultations, and web or satellite broadcasts. They also provide publications, newsletters, computer programs, videotapes and other educational materials.

Agriculture and its associated industry segments represent nearly 12% of Kentucky's total economic activity and approximately 15% of Kentucky jobs. As one of Kentucky's largest industries, it remains vitally important to every community and region in the state. However, the focus of Kentucky agriculture varies greatly from community to community and region to region. It is very important that regions and communities understand renewable energy and energy efficiency opportunities as they apply to the agricultural enterprises in their specific areas. It is vital for the most qualified organization to provide leadership in this effort.

Kentucky's agricultural community must fully support the goals of 25x'25 for the vision to come to fruition. Through an ongoing dialogue created and supported through an interaction with all of Kentucky's key agricultural partners within the agriculture and forestry sectors, and through partnerships with other energy stakeholders, the Kentucky 25x'25 initiative is in a very strong position to communicate to the public that Kentucky's farms and forests are a key component of a new state and national energy strategy.

Recommendation #4. Empower state agencies to lead the way

Require that all new buildings built for the Executive Branch, Judicial Branch, and public universities be designed and constructed to meet or exceed ENERGY STAR® certification requirements. Through state incentives, encourage home builders to build homes that meet or exceed ENERGY STAR® certification requirements. Provide state incentives for homeowners to improve the energy efficiency of their own homes, improving overall efficiency of the state's existing housing stock.

State government has the opportunity to attain substantial savings in energy costs by increasing the efficiency of state buildings. These savings can be used to improve other state services for the benefit of all Kentuckians. Kentucky's economy also can benefit from improvements in energy efficiency in housing and construction. Incorporation of energy-efficient features in new construction can create additional jobs and provide markets for new products that can be engineered and manufactured in Kentucky. Improving energy efficiency in existing structures offers similar opportunities. Although Kentucky is fortunate to have some of the lowest energy costs in the nation, increasing energy efficiency nonetheless can provide significant savings. This would increase disposable income and increase economic activity. Furthermore, energy conservation can increase the supply of energy available for new economic growth without incurring the cost of providing new energy supply infrastructure.

A Task Force on Energy Efficient Housing and Construction was initiated recently in Kentucky to draw on the expertise of agencies within the Department of Public Protection to find opportunities for greater energy efficiency in Kentucky's housing and construction industries. The primary topics the Task Force examined were increasing energy efficiency in homes and other structures and minimizing energy use and waste during construction. The KREC Core Team believes that these recommendations should be re-examined and supported.

The ENERGY STAR® program is a joint effort of the U.S. Environmental Protection Agency and the U.S. Department of Energy helping us all save money and protect the environment through energy efficient products and practices.

Americans, with the help of ENERGY STAR®, saved enough energy in 2006 alone to avoid greenhouse gas emissions equivalent to those from 25 million cars – all while saving $14 billion on their utility bills.

Energy efficient choices can save families about a third on their energy bill with similar savings of greenhouse gas emissions, without sacrificing features, style, or comfort. The Energy Star designation is applied to new household products that meet strict energy efficiency guidelines set by the EPA and U.S. Department of Energy. The ENERGY STAR® certification also applies to new homes.

Because a strategic approach to energy management can produce twice the savings – for the bottom line and the environment – EPA's ENERGY STAR® partnership offers a proven energy management strategy that helps measure current energy performance, set goals, track savings, and reward improvements. EPA provides an innovative energy performance rating system that businesses have already used for more than 30,000 buildings across the country. EPA also recognizes top performing buildings with the ENERGY STAR®.

Under the federal Energy Policy Act of 2005 (EPACT 2005), a $2000 tax credit is available for a new energy-efficient home that achieves 50 percent energy savings for heating and cooling over the 2004 International Energy Conservation Code (IECC). The Kentucky ENERGY STAR® new home tax credit would complement the federal credit and create an incentive for Kentucky home builders to build a more energy-efficient home that would also qualify for the federal credit. While attaining the Energy Star standard would increase the initial cost of a home, a recent University of Kentucky study showed that the monthly energy savings would exceed the additional mortgage cost. The KREC Core Team agrees with the Energy Efficiency Task Force proposal for an $800 income tax credit to the builder for each certified home. Builders who meet or exceed an Energy Star or LEED standard deserve additional recognition. This recognition could be tiered, based upon the number of homes constructed, Home Energy Rating System (HERS) rating, or other criteria, and should be subject to third-party validation. The positive publicity attendant to this recognition could provide an incentive for builders to improve energy efficiency.

The Governor's Office of Energy Policy and the Office of Housing, Buildings, and Construction can develop partnerships with the Homebuilders Associations across the Commonwealth to educate Kentucky's builders on how to become eligible for federal tax credits for energy-efficient new construction. This educational effort would provide an opportunity for the Governor and other state government leaders to directly address members of a key economic sector and to emphasize the importance of energy efficiency to the continued health and growth of Kentucky's economy.

State incentives for homeowners to invest in weatherization also has the potential to provide the most rapid, enduring, and cost effective improvement in energy efficiency of Kentucky's housing inventory. Improvements such as additional insulation, modern windows and doors, and more efficient HVAC systems have an immediate and lasting impact on energy consumption. There is a substantial backlog of older homes in dire need of energy efficiency improvements. The assistance provided by weatherization programs would largely accrue to Kentucky residents on low or fixed incomes – the segment of the population that most needs the benefits from reduced residential utility costs.

Possible other incentives for homeowners to purchase energy efficient homes and appliances and to make energy-conserving home improvements include:

(a) incentives such as tax credits, sales tax waivers, cash rebates, and low-interest loans for the purchase of energy-efficient equipment and supplies or other weatherization efforts.

(b) Energy Efficient Mortgages (EEM), an existing incentive provided through the federal Housing and Urban Development program and Fannie Mae which are rarely used in Kentucky. State government could work to identify any impediments to the use of EEMs in Kentucky and determine how to lower those barriers.

(c) energy-efficiency development zones could be created in neighborhoods with older housing stock, with a time-delimited program of tax incentives to encourage energy efficient retrofits of those homes.

Efforts to improve energy efficiency and conservation should be an essential and central element of energy policy. The KREC Core Team believes that improving the energy efficiency of housing and other buildings has the potential to make a significant contribution to the overall goal of an energy policy that maintains and improves the health of Kentucky's economy, environment, and people.

Recommendation #5- Establish biofuels incentive programs for state university fleets

Require a renewable fuel standard (RFS) using ethanol and biodiesel for state agencies and public universities that operate state-owned vehicle fleets, and hold state agencies accountable for achieving RFS targets.

When petroleum is burned, carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NOx), sulfur oxides (SOx), volatile organic compounds (VOCs,) also known as reactive hydrocarbons), hydroxyl ions (OH-), and particulate matter (PM) are emitted. Additionally, NOx and reactive hydrocarbons form low-level ozone (O_3) (a major component of smog) in the presence of sunlight.

These pollutants have numerous health and environmental impacts, including urban smog and global climate change. Burning the fuels is not the only environmental risk. The extraction and transportation of petroleum can also have significant environmental impact.

In Kentucky, the Finance and Administration Cabinet is required to develop a strategy to replace at least 50 percent of state motor fleet light-duty vehicles with energy-efficient vehicles, including hybrid-electric vehicles, fuel cell vehicles, and alternative fuel vehicles. The Finance and Administration Cabinet has also developed a strategy to increase the use of ethanol, biodiesel, and other alternative fuels in state motor fleet vehicles. The Kentucky Transportation Cabinet and the Finance and Administration Cabinet must establish procurement contracts that maximize the market availability of E10 and B2 blends. Additionally, employees using conventional vehicles in the Transportation Cabinet's fleet are directed to use either E10 or B2 as their primary fueling option, and the Transportation Cabinet is directed to maximize the use of E85 in its fleet of flexible fuel vehicles.

To ensure that Kentucky will become a leader in securing U.S. energy independence, the Kentucky Energy Security National Leadership Act directs the Commonwealth's Office of Energy Policy to develop and implement a strategy for the production of alternative transportation fuels and synthetic natural gas from fossil energy resources and biomass resources, including biodiesel and ethanol. The strategy must include establishment or expansion of state government incentives for developing, constructing, or operating alternative transportation fuels and synthetic natural gas production facilities; oversee the state's comprehensive energy strategy; support of alternative energy through awareness and technology development; and administer grant programs to support energy-related research. (House Bill 1, 2007, and Kentucky Revised Statutes 152.710 to 152.725)

The codification of these requirements into a Renewable Fuels Standard (RFS) for the state vehicle fleet was recommended by the 25x'25 Advisory Board. The primary goal is for state agencies to set an example with the vehicle fleet and to help increase ethanol and biodiesel production and use within Kentucky. By encouraging the production and use of domestic fuels and the industries that surround them, we help create thousands of new jobs in Kentucky. Domestic fuel development also increases our energy independence, allowing us to gain more control of our state's and country's future.

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Kentucky Resources to Meet the Energy Needs of the 25x'25 Initiative

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COOPERATIVE EXTENSION SERVICE
University of Kentucky – College of Agriculture

A White Paper on

Kentucky Resources to Meet the Energy Needs of the 25x'25 Initiative[1]

by – Donald Colliver[2], James Bush[2], Alison Davis[3], Mike Montross[2], Robert Fehr[2], Richard Gates[2], Greg Halich[3], and Sue Nokes[2]; College of Agriculture, University of Kentucky

The purpose of this paper is to present the results of an analysis of the current energy usage in Kentucky, projected energy usage in 2025, and the potential for options for energy savings and renewable energy production.

1.0 Current Energy Usage

The official energy statistics from the U.S. Government are published by the Energy Information Agency[4]. Presented in Figure 1 is a national overview of the sources of energy and where this energy is used.

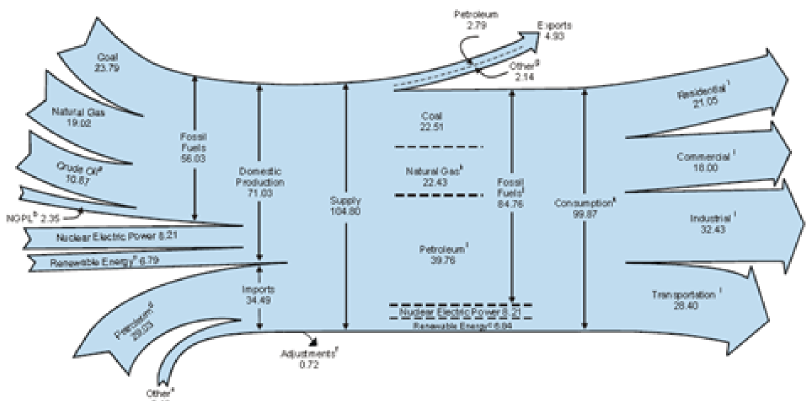

Figure 1. National Energy Flows, 2006 (Quadrillion Btu)[5]

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[1] University of Kentucky, College of Agriculture, Research Manuscript Number 08-05-038, revised 7-24-08

[2] Biosystems and Agricultural Engineering Department, University of Kentucky

[3] Agricultural Economics Department, University of Kentucky

[4] US Energy Information Administration, http://www.eia.doe.gov/

[5] US EIA http://www.eia.doe.gov/emeu/aer/pdf/pages/sec1_3.pdf

This information is given on the energy content of the primary fuel that is used in the four energy use sectors (residential, commercial, industrial, and transportation). Therefore it is classified as the “Source” or “Primary” energy usage. This is not a summation of the energy flows that would be measured by the electrical or gas meter at the end point-of-use because these meters do not take into account the energy losses which occur in generation and transmission. The measurement of energy at the point-of-use is classified as “Site” energy and is typically what is recognizable by the consumer.

The 2004 annual site energy usage in Kentucky was 472.5 million Btu per person[6] which ranked it as 8th highest state energy consumption in the US. The annual energy expenditures for Kentucky was $3,353/person which was 11th nationwide even though Kentucky ranked near the bottom (44th nationwide) in energy prices. While part of this discrepancy could be attributed to some very high energy use industries, it is evident that the personal energy expenditures were high.

Historical annual energy usage by state for each of the sectors are given in the EIA State Energy Consumption, Price and Expenditure Estimates (SEDS)[7] dataset. Long-term projections of future energy consumption, however, are made on a regional basis. The projections for the energy consumption by sector for Kentucky are combined with other states in the East South Central region of the EIA Annual Energy Outlook (AEO)[8]. Therefore in order to use the regional values predicted in the AEO as the basis for Kentucky’s projected usage, Kentucky’s fraction of the existing East South Central region usage (25.65%) was assumed to continue into the future.

The energy used in 2005 in Kentucky is presented in Table 1 and Figure 2 for the four sectors.

Table 1. Site and Source Energy Used in 2005 in Kentucky[9,10], Quad/yr[11]

	Site Energy	Source Energy
Residential	0.168	0.370
Commercial	0.117	0.260
Industrial	0.539	0.864
Transportation	0.477	0.477
Total	1.301	1.970

[6] Table 1.6 State-Level Energy Consumption, Expenditures, and Prices, 2004 http://www.eia.doe.gov/emeu/aer/pdf/pages/sec1_15.pdf
[7] http://www.eia.doe.gov/emeu/states/sep_use/total/pdf/use_ky.pdf
[8] http://www.eia.doe.gov/oiaf/archive/aeo06/supplement/pdf/suptab_6.pdf
[9] Site energy from Net Energy column in Tables S4, S5, S6, and S7 of http://www.eia.doe.gov/emeu/states/_seds.html
[10] Source energy from http://www.eia.doe.gov/emeu/states/sep_sum/html/pdf/sum_btu_1.pdf
[11] One Quad/yr is 1,000 trillion (1,000,000,000,000,000 or 10^{15}) btu/yr

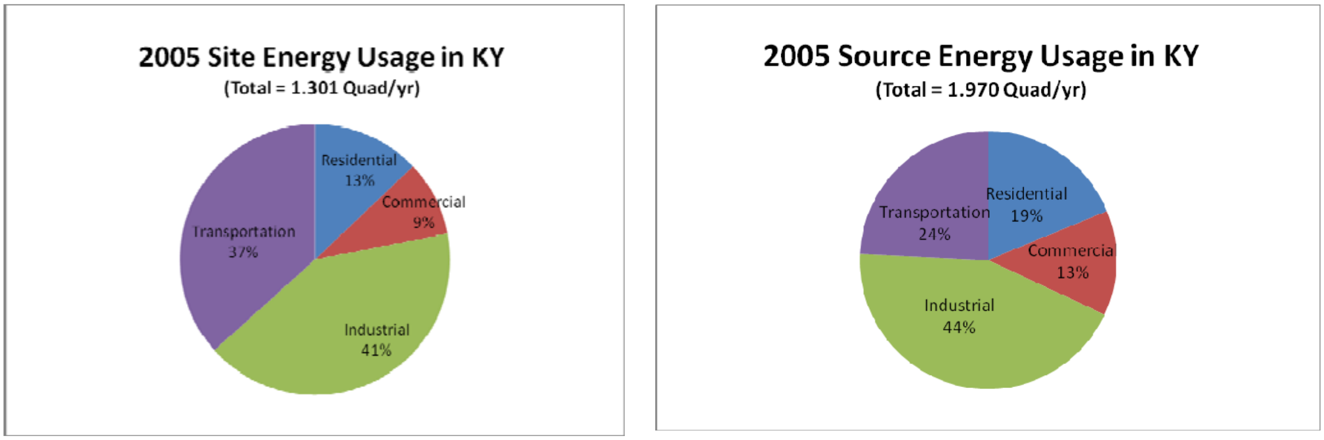


Figure 2a and 2b. 2005 Distribution of Site and Source Energy Usage by Sector in KY

The significant differences in the percentages of each sector between the site and source usage is mainly due to the differences in the type of energy used in the sectors. Electricity is a large fraction of the residential and commercial sectors use. Electricity has the largest difference between site and source energy with a 3.2 conversion between source and site energy for 2005 in KY. Therefore when the site energy is converted by sector to source energy it becomes a larger fraction of the total.

2.0 Projected Energy Usage in 2025

The projections for the annual energy consumption until 2030 are given for the East South Central region of the US in the EIA Annual Energy Outlook (AEO)[12]. In order to use the AEO as the basis for the state's projected usage, Kentucky's fraction of the existing East South Central region usage (25.65%) was assumed to continue into the future.

The projected energy used in 2025 in Kentucky is presented in Table 2 and Figure 3 for the four sectors.

Table 2. AEO Predicted Site and Source Energy Used in 2025 in Kentucky, Quad/yr

	Site Energy	Source Energy
Residential	0.195	0.536
Commercial	0.181	0.527
Industrial	0.626	1.147
Transportation	0.601	0.605
Total	1.603	2.815

[12] http://www.eia.doe.gov/oiaf/archive/aeo06/supplement/pdf/suptab_6.pdf

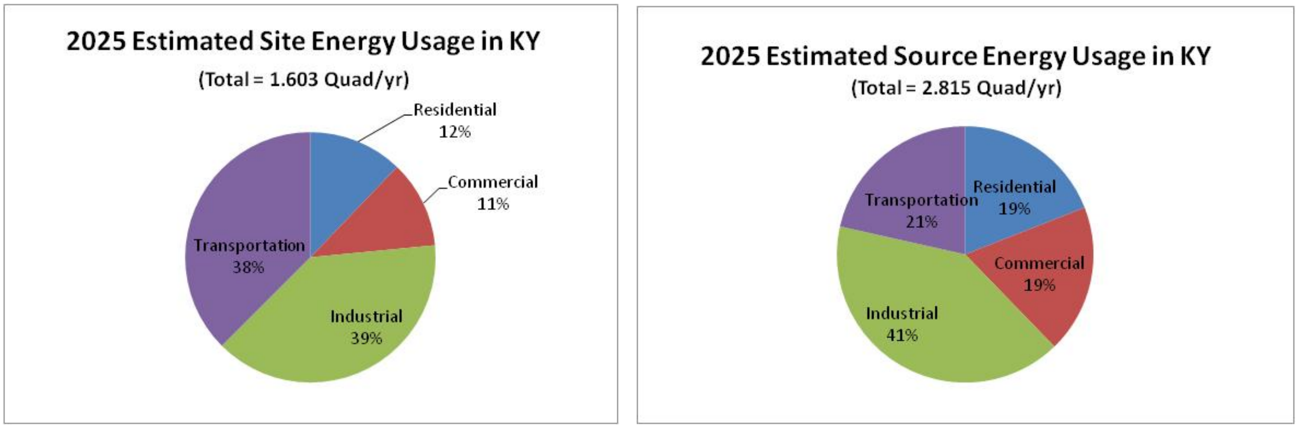


Figure 3a and 3b. Distribution of Predicted 2025 Site and Source Energy by Sector

It should be noted that there are significant differences within the EIA data regarding the current site energy usage of the different sectors. This greatly impacts the estimates for future energy usage. For example, the EIA Annual Energy Outlook (AEO) indicates that the national commercial energy use intensity (EUI) is 114.8 kBtu/sqft-yr[13] whereas the EIA Commercial Buildings Energy Consumption Survey (CBECS)[14] indicates the national commercial EUI is 91.0 kBtu/sqft-yr. This is a difference of about 21%. Similar differences occur in the residential sector. Repeated attempts with the EIA[15,16], other DOE personnel[17] and researchers in the national laboratories[18] who use these data have not been able to resolve or explain these differences. It was indicated however that the federal energy guidelines are based upon the CBECS values. Therefore for this analysis, the 2025 predicted values were the current CBECS values increased by the predicted increase given in the AEO.

[13] http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_5.xls cell B18

[14] http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set14/2003excel/c1a.xls

[15] Personal Communication. EIA Contact Center. Paul Holberg

[16] Personal Communication. Erin Bodecker. EIA

[17] Personal Communication. Drury Crawley. US DOE.

[18] Personal Communication. Mark Halverson PNNL and Brent Griffith NREL.

3.0 Potential of Energy Efficiency Options for Energy Savings

The energy savings potential for implementation of a number of energy efficiency options in the residential, commercial and transportation sectors are given in the following section. The industrial sector was not included in the scope of this analysis.

3.1 Residential

This section estimates the energy savings potential of Kentucky's residential sector in 2025. Energy savings are calculated relative to a base case home constructed in 2007. They represent the impact of all improvements made during the 18 year period, 2008 through 2025.

Energy savings are allocated to one of three areas:

1. Base Case improvement in energy efficiency over time,
2. Improvements made to the existing housing stock, and
3. Improvements made to new housing construction.

The Base Case represents a general policy toward energy efficiency that encourages the adoption of a more efficient technology when items such as appliances and HVAC equipment are replaced. The Base Case is consistent with the EIA's projection of relatively flat residential energy use per capita[19] even though additional energy using devices are adopted in the home. Improvements to existing housing stock and new construction represent more aggressive, targeted programs for energy efficiency.

3.1.1 Total Housing Units and Growth

Total residential housing units[20] for Kentucky by year are presented in Figure 4. The number of housing units is expected to increase from 1.91 million in 2008 to 2.28 million in 2025. The existing housing stock, based on 2006 U.S. Census data[21], accounts for 1.89 million units and is assumed constant during the period. The analysis assumes that 388,191 new housing units will be constructed between 2008 and 2025 (21,566

[19] Figure 27: Annual Energy Outlook 2007 with Projections to 2030. Energy Information Agency.

[20] A residential housing unit includes single family residences, apartments, condominiums, manufactured houses and units in low-rise residential complexes but does not include high-rise residential units.

[21] Table 1: Annual Estimates of Housing Units for the United States and States: April 1, 2000 to July 1, 2006 (HU-EST2006-01). Population Division, U.S. Census Bureau.

new households per year on average), based on the trend in new housing starts that occurred from 2000 to 2006[22].

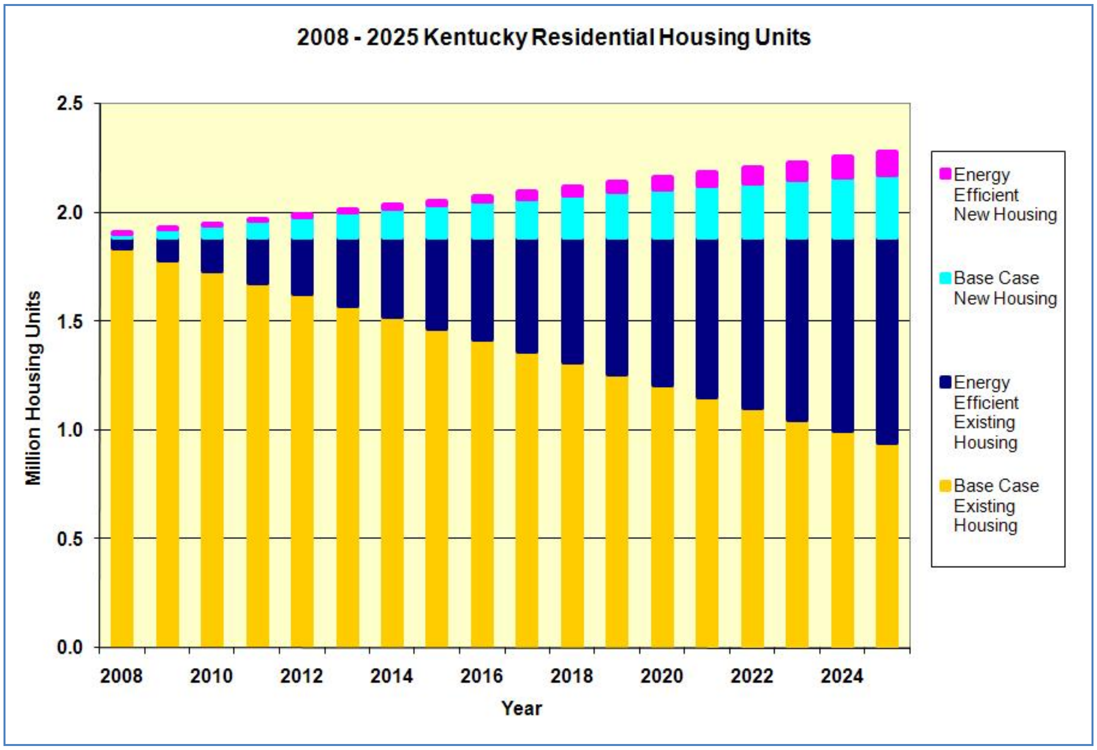


Figure 4. Total Residential Housing Units for Kentucky by Year

3.1.2 Energy Use per Household and Energy Improvement Strategies

For the existing housing stock, Base Case energy consumption per household is assumed to mirror the average for the East South Central Region from the 2001 EIA Residential Energy Consumption Survey[23] and will decrease 0.5% per year through 2025. The energy consumption for new construction in 2008 is derived from a typical Kentucky house that just meets the 2006 International Residential Code[24], also decreasing 0.5% per year through 2025.

Improvements to existing housing units assume that between 2008 and 2025 one-half of the existing housing stock (52,489 households per year) will implement energy efficiency measures sufficient to reduce their Base Case energy consumption by 20%.

[22] Housing Units Authorized by Building Permits: Table 2 – United States, Region, Division and State, Annual Data. U.S. Census Bureau.
[23] Table CE1-11c. Total Energy Consumption in U.S. Households by South Census Region, 2001. Energy Information Agency.
[24] REM/Rate estimate of 2000 ft^2 house in Lexington, KY modified to HERS Index of 100.

Examples of these types of measures include better air sealing, added insulation and/or improved HVAC systems.

Improvements to new housing construction assume that a growing portion of new housing starts will consume 15% less energy than their peers. This is equivalent to today's criteria for ENERGY STAR certification. It is assumed that the adoption rate of these new energy efficient houses increases by 2.8% per year which results in one-half of all new housing starts in 2025 exceeding new Base Case performance by 15%. A summary of these energy consumption assumptions is presented in Table 3.

Table 3. Energy Consumption per Household, (site energy, million Btu/yr)

Year	Existing Housing Stock		New Housing Construction	
	Base Case millionBtu/yr	Energy Efficient millionBtu/yr	Base Case millionBtu/yr	Energy Efficient millionBtu/yr
2007	76.4	na	72.8	na
2008	76.0	60.8	72.4	61.6
:	:	:	:	:
2025	69.3	55.4	66.0	56.1

3.1.3 Residential Energy Savings Potential

Kentucky households could reduce site energy consumption by 30.9 trillion btu (tbtu) in 2025. Energy efficiency improvements to the existing housing stock account for 88% of the reduction (27.2 tBtu). Improvements to new housing construction account for 12% (3.7 tBtu). Annual savings for the 2008 to 2025 period are presented in Figure 5.

Residential energy consumption in 2025 would be 172.6 tBtu if the housing stock operated at 2007 levels of efficiency and there were no improvements in energy efficiency. Energy improvements strategies have the potential to reduce energy consumption in 2025 to 141.7 tBtu.

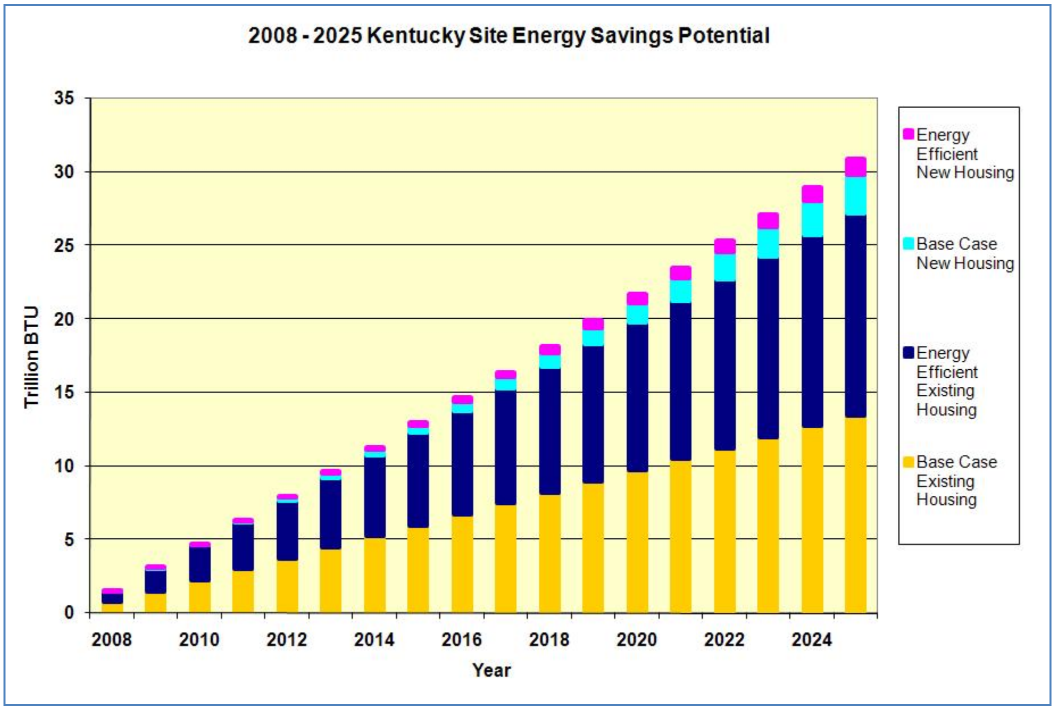


Figure 5. Annual Residential Energy Savings Potential

Assuming recent energy prices[25] escalate 3% annually and the typical fuel mix in the residential sector remains the same[26], the equivalent source energy savings would be as presented in Table 4.

Table 4. Kentucky Residential Source Energy Savings Potential - 2025

Kentucky Residential Sector 2025 Source Energy Savings Potential
70.7 trillion Btu (5,524,000 megawatt-hours electricity) (11,680,000 thousand cubic feet natural gas) $703,130,000 17.9% reduction

[25] $0.0611 per kWh; $10.97 per Mcf. 2004 Residential Sector price, Kentucky. Energy Information Agency.

[26] 61% electricity; 39% other. 2001 Residential Energy Consumption Survey, East South Central Region. Energy Information Agency.

3.2 Commercial

3.2.1 Total Building Area and Growth

The total area of commercial buildings in Kentucky by year is presented in Figure 6. The estimated total area is the area of the post-2003 era buildings plus the area of the new construction after that time. Based upon the energy use fraction of the east south central region there were approximately 886 million square feet of commercial building space in Kentucky in 2004[27] or 214 sq ft per person. It is assumed that the building area per person in the future will remain the same. Therefore the total building area will be proportional to the population and will increase at the same rate as the state's population as estimated by KSDC[28]. It is also assumed that the life of a commercial building (or the life between extensive major renovations) is 50 years. Assuming the existing building stock (i.e. 2003-era buildings) was uniformly constructed over the previous 50 years, 2% of the 2003-era buildings will be replaced each year. Therefore the new buildings constructed each year will be a combination of the increase in building size due to population growth and the replacement of 2003-era buildings. The long-term effect of the current building stock on the total building inventory in the future can be seen from Figure 6.

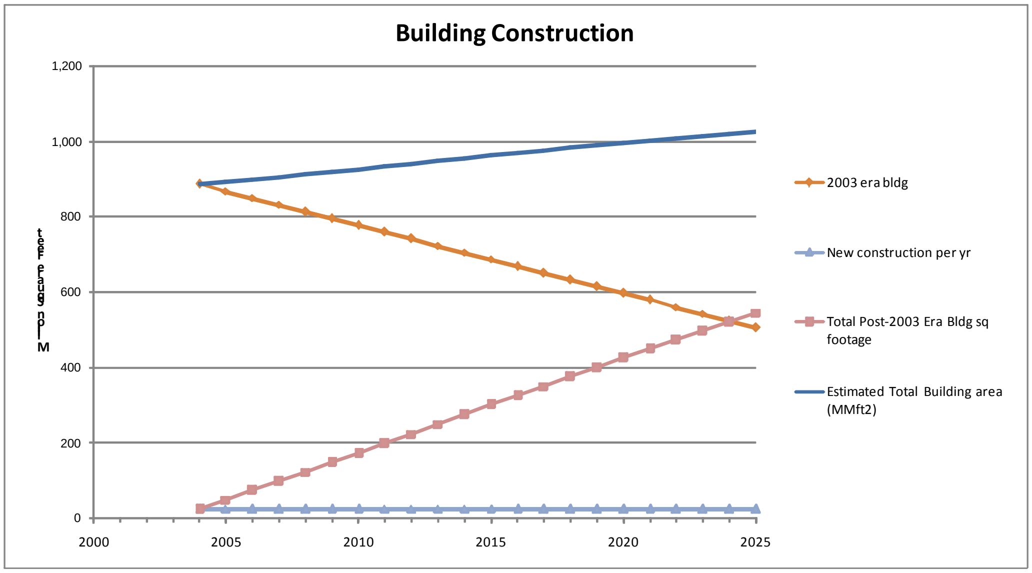


Figure 6. Area of Commercial Buildings in Kentucky

[27] Table A4 Census Region and Division, Floorspace for all buildings. CBECS.

[28] KSDC, Historical and Projected Household Populations, Number of Households, and Average Household Size. State of Kentucky.

3.2.2 Energy Use Intensity (EUI) and Optional Strategies for Change over Time

The results of four different strategies to conserve energy are indicated in the EUIs presented in Figure 7. Note that these are “site” EUIs in all cases. Conversion to source energy will be considered later.

Option 0 (Base Case) : EIA Projected Increase in EUI - The EIA Annual Energy Outlook EUI long-term projections for the commercial sector increased over time due to the projected increase in use of electronic equipment despite anticipated improved efficiencies in equipment.

Option 1: EUI remain constant over time – This option assumes that any increases in equipment are off-set by improved efficiencies in all equipment and new buildings will have the same EUI as existing buildings.

Option 2: EUI for 90.1 code – This option assumes that existing buildings will have the same EUI as they currently have and all new buildings will be built and operate at the energy levels given in Standard 90.1-2004 – the basis for the commercial model energy codes[29]

Option 3: EUI decreased by 30% every five years on new buildings – This option assumes that existing buildings will have the same EUI as they had in 2004 and all new buildings will be built and operated at the energy levels given in Standard 90.1; and the levels given in Standard 90.1 are reduced by 30% in 2010 and a further 30% reduction every five years thereafter. This option is roughly based upon the Zero Energy Building by 2025 goals of the USDOE, ASHRAE, AIA, and Architecture 2030 and the mandate given for federal buildings in the 2007 Energy Act.

[29] 2004. ASHRAE. ANSI/ASHRAE/IESNA Standard 90.1-2004 Energy Standard for Buildings Except Low-Rise Residential Buildings.

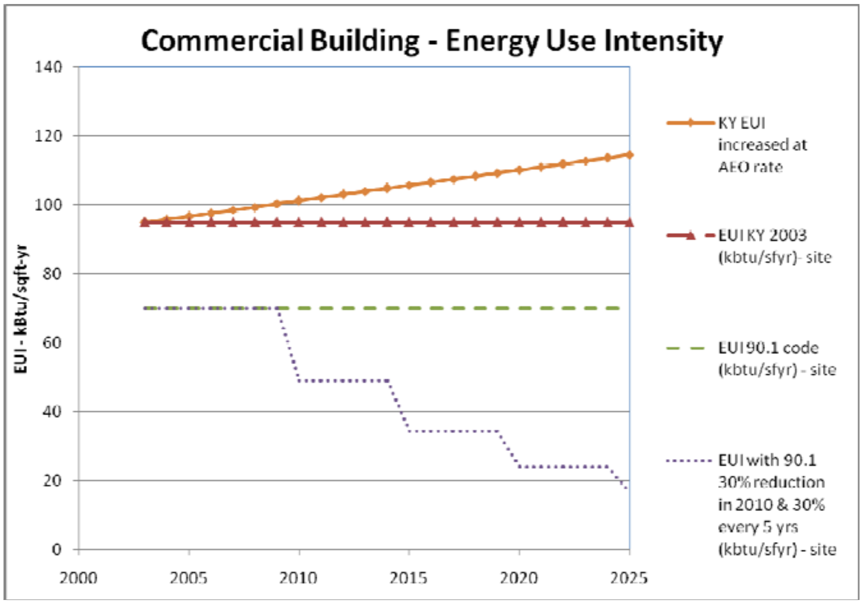


Figure 7. Energy Use Intensities Based on Varying Assumptions

3.2.3 Projected Total Commercial Energy Use With Energy Efficiency Optional Strategies

The total projected commercial energy uses with the different EUI strategies are presented in Figure 8. The amount of site and source energy savings in 2025 using the different energy efficiency optional strategies are presented in Table 5.

It can be seen that by applying the existing building codes and assuring that the buildings are built and operated to code and that additional equipment is offset by increases in energy efficient can save 33.6 (site) and 103.8 (source) tbtu/yr. Using an strategy of implementing aggressive building codes can save 47.3 (site) and 146.0 (source) tbtu/yr. The small effect between these two significantly different measures illustrates the importance of implementing strategies which will mainly impact the existing building stock.

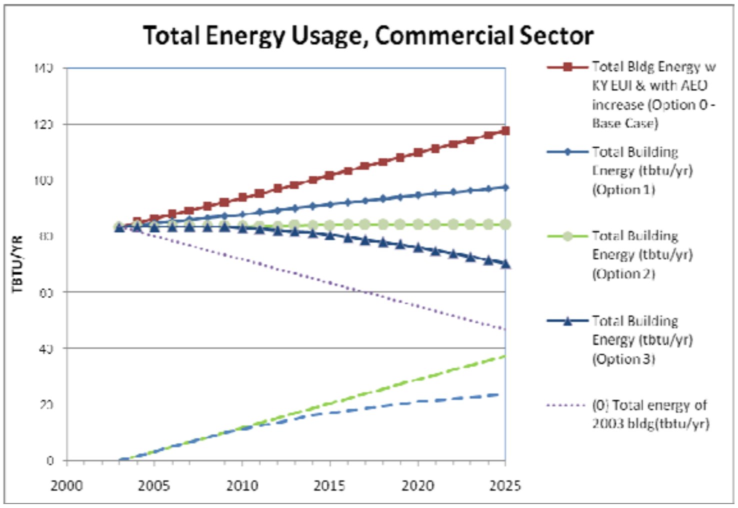


Figure 8. Projected Total Commercial Site Energy Usage using Different Energy Saving Options

Table 5. Total Energy Usage - Commerical Sector with Different Energy Saving Options, (tbtu/yr)

	2025 Usage (Site Energy)	Savings from Base Case (tbtu/yr)	
		Site Energy	Source Energy
Base Case - Assumed EUI increased as per AEO	117.7		
Option 1 - Assumed Constant EUI	97.5	20.2	62.3
Option 2 – Assumed New Buildings have 90.1 code usage	84.1	33.6	103.8
Option 3 – Assume New Buildings built to advanced code	70.4	47.3	146.0

3.3 Transportation

The energy usage in the transportation sector in Kentucky is significant. However federal guidelines and requirements take precedence over state laws or initiatives. Therefore, we will only present the effects of the requirements of the 2007 Energy Independence and Security Act[30]. The act requires the Department of Transportation to set tougher fuel economy standards, starting with model year 2011, until the standards achieve a combined average fuel economy for model year 2020 of at least 35 miles per gallon (mpg). The standards apply to the total fleet of passenger and non-passenger automobiles manufactured for sale in the United States for that model year, up to a gross vehicle weight of 10,000 pounds. Currently, passenger automobiles must achieve an average of 27.5 mpg, while "light trucks"—a category that includes pickup trucks, sport utility vehicles, and minivans—must achieve 22.5 mpg, bringing the average for cars and light trucks to about 25 mpg.

The effect of this increase in transportation energy efficiency will be significant. It is estimated that 62 tBtu could be saved in 2025 if we improve the fuel economy of light duty vehicles from 28.9 mpg (the projection used in 2006 AEO) to 35.0 mpg (the requirement of the 2007 Energy Independence and Security Act)

4.0 Potential Renewable Energy Options

4.1 Biofuels - Renewable Liquid Fuel Production from KY Agricultural Resources

Liquid fuels from starch sources and grasses (corn stover, hay, switchgrass, and wheat straw) were considered due to their conversion ease. Wood residues are harder to convert to ethanol and for this analysis are assumed to be used for combustion purposes for electricity production only. Kentucky's gasoline consumption was 2,320 million gallons per year during 2004 and ethanol contains 70% of the energy content of gasoline. The fuel production and costs are based on current prices and available land resources. The IMPLAN[31] computer model was used to evaluate the potential impact in the three regions of the state. The regions were summed together to provide a state level impact on value-added to the state due to construction investment, annual value-added revenue, increased state taxes, jobs created during construction, and new jobs created for operating plants producing ethanol.

[30] http://www.eere.energy.gov/news/archive.cfm/pubDate=%7Bd%20%272008%2D01%2D02%27%7D
[31] http://www.implan.com

Overall, Kentucky could replace up to 21% of its gasoline consumption in 2004 using current land resources and costs. Construction of plants to produce this amount of biofuel would result in 130 million dollars of value-added benefits in Kentucky. On an annual basis, ethanol production would be expected to add up to 355 million dollars per year to the state economy and create 2,244 new permanent jobs. Tax revenue would increase by 3.1 million dollars per year. The total investment in the ethanol plants would be close to 600 million dollars with a resulting ethanol cost of $1.55/gal. On an equal energy basis compared to gasoline, this would be the equivalent of $2.21/gal (neglecting any road and sales taxes).

Table 6. Overall potential impact of ethanol production in Kentucky.

	Cost ($ thousands)	Jobs
Value-added due to construction	130,390	2,244
Value-added (per year)	355,520	1,832
State taxes (per year)	3,070	
Percent gasoline displaced[1]	21.2%	

[1]Percent of 2004 gasoline consumption displaced

Ethanol from Corn

The simplest product to convert to ethanol is the starch from corn grain. Based on statistics from USDA[32], Kentucky produced, on average, approximately 1.4% of the nation's corn crop over the past five years. During the previous year, 5.4 billion gallons of ethanol were produced[33] using approximately 20% of the US corn crop. Assuming Kentucky would produce 1.4% of the ethanol, approximately 63 million gallons per year of ethanol could be produced from 32 million bushels of corn each year.

However, increased ethanol consumption will result in greater production of corn that will be converted into ethanol. This was estimated using corn's demand elasticity which estimates how much of a demand reduction will likely occur for corn's use as food, animal feed, and other uses, given that the price of corn increases as ethanol plants expand. This decrease in demand is assumed to be transferred to corn-based ethanol production. Estimates for increases in additional corn acreage due to conversion from fallow ground, hay ground, and other row crops are also used in this analysis. Three

[32] USDA National Agricultural Statistics Service – http://www.nass.usda.gov

[33] Renewable Fuels Association - http://www.ethanolrfa.org/industry/outlook/

scenarios (low, medium, and high corn price) were investigated, however, only the mid-level estimate is discussed.

The base price for corn used in this analysis is $3.75 per bushel. This reflects an average price at which corn could be purchased during the last half-year (2007). Under this scenario, a corn price of $5.00/bu could be supported and Kentucky would produce an additional 44 million bushels of corn per year that would be converted to ethanol. This would result in a total ethanol production of 186 million gpy.

The majority of the corn production is in the western portion of the state and it is assumed all plants are located in Western Kentucky. The additional corn production would support approximately three additional ethanol plants with a capacity of 48 million gpy (since there is currently one plant in Western Kentucky). Table 7 summarizes the impact of increased corn production and ethanol production within Kentucky. Additional corn and ethanol production could displace 6.7% of Kentucky gasoline consumption. This would require an ethanol selling price of $1.96/gal or the equivalent of $2.57/gal on a btu basis relative to gasoline.

Table 7. Overall impact of increased corn and ethanol production in Kentucky.

	Cost ($ thousands)	Jobs
Value-added due to construction	16,737	332
Value-added (per year)	83,240	722
State taxes (per year)	1,001	
Percent gasoline displaced[1]	6.7	

[1]Percent of 2004 gasoline consumption displaced

Ethanol from Switchgrass and Crop Residues

The initial production of ethanol from lignocellulosic materials would probably be done by converting crop residues and hay other than alfalfa or “other-hay”. Other-hay has a lower value than alfalfa hay. Kentucky has 2.15 million acres of land in other-hay with an annual yield of 2.3 ton/ac[34]. A significant land source in Kentucky for renewable energy production could originate from other-hay crop land. The scenario investigated was 25% of the other-hay land would be converted to switchgrass. It was assumed that switchgrass would have the same price as hay or farmers would not produce it.

[34] USDA-NASS - National Agricultural Statistics Service - www.nass.usda.gov

Three scenarios were investigated and the lower end estimate would see an increase in hay prices from 50 to $63/ton due to increased demand for land being used for ethanol production. In addition, this could result in a higher income per acre for farmers since the expected yield from switchgrass is 8 ton/ac. Delivery of biomass to the production plant was estimated at $20/ton resulting in a feedstock price of $83/ton at the plant gate. This assumed a net increase in hay acreage of five percent due to the increased demand for hay.

Agricultural residues such as corn stover and wheat straw could also be collected to produce ethanol. Kentucky has averaged 1.1 million acres of corn and 0.3 million acres of wheat. An upper limit of residues that could be sustainably collected would be on the order of 1 ton/ac for corn stover and 1.25 ton/ac for wheat straw. This would result in an additional 1.5 million tons of material a year that could be collected with an average ethanol yield of 80 gal/ton. The total near-term production of ethanol from cellulosic crops would be 121 million gpy.

If 25% of the other-hay crop land was converted to switchgrass production with a yield of 8 ton/ac, 4.51 million tons/yr of switchgrass would be available for ethanol production. Under this scenario switchgrass alone could produce 361 million gpy of ethanol (or 253 million gpy of gasoline equivalent). When combined with 186 million gpy from corn grain and 121 million gpy from agricultural residues, Kentucky could displace up to 21.4% of the gasoline consumption in 2004.

Table 8. Overall impact of diverting 25% of the other-hay acreage to switchgrass and collecting agricultural residues for cellulosic ethanol conversion.

	Cost ($ thousands)	Jobs
Value-added due to construction	113,650	1,912
Value-added (per year)	272,280	1,110
State taxes (per year)	2,070	
Percent gasoline displaced[1]	14.5%	

[1]Percent of 2004 gasoline consumption displaced

Biodiesel from Oilseeds

Production of biodiesel requires fats or oils as a feedstock. In the US, these fats are provided primarily by soybeans. If Kentucky consumed 25% of the soybean crop for biodiesel production, 1.35% of the diesel fuel could be displaced. Alternative oilseed crops have been investigated that utilize winter canola in a double-crop rotation with sunflowers. This has the advantage of increasing the oil yield per acre. If 25% of the soybean acreage and 25% of the wheat acreage was converted to a canola/sunflower double crop rotation 8.1% of the diesel fuel could be displaced. Development of new cropping systems (canola, sunflower, algae, etc.) will be required to significantly impact the distillate fuel consumption in Kentucky.

Biofuels Summary

An analysis done on the converting some of Kentucky's agricultural resources into renewable energy[35] indicated a significant amount of energy could be obtained by converting corn, switchgrass, corn stover, and wheat straw to ethanol and vegetable oil to biodiesel. A summary is presented in Table 9. The total potential production is 65.6 tBtu/yr if corn, corn stover, wheat straw, switchgrass, and vegetable oil are converted.

Table 9. Potential Ethanol and Biodiesel Produced in Kentucky from Biomass Fuels,

	Million Gal/yr	tBtu/yr
Corn	186	14.1
Switchgrass	361	27.4
Corn Stover + Residues	121	9.2
Vegetable Oil to Biodiesel	107	14.9
Total		65.6

4.2 Solar Water Heaters

The amount of energy saved by installing a 32 or 64 ft^2 solar collector on new houses is presented in Figure 9a. These are two popular sizes of heaters installed. The three lines are based upon the number of solar heaters installed: 10-, 20-, or 30% of the estimated 388,191 new homes built between 2008 and 2025. This represents 38,819, 77,638, and 116,457 houses respectively for the 10-, 20- and 30% market penetration.

The range of site energy saved was between 0.32 and 0.96 tBtu/yr for the 64 ft^2 heater. The summary of energy savings table assumes 64 ft^2 and 20% market penetration.

[35] Nokes S., A. Reum, M. Montross, and G Hallick. 2007. Study of the Economics of Converting Some of Kentucky's Natural Resources into Renewable Energy. Biosystems and Agricultural Engineering Department. University of Kentucky.

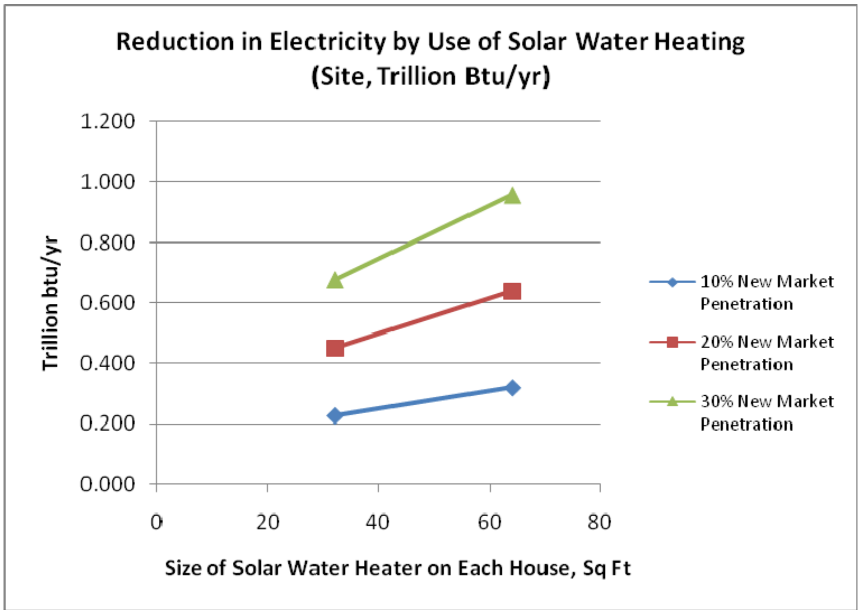


Figure 9a. The Site Energy Savings due to Installation of Solar Water Heaters on New Houses between 2008 and 2025

Using solar to heat water rather than electricity or gas also reduces the amount of CO_2 produced. This reduction is presented in Figure 9b for the use of 32 and 64 ft^2 solar water heaters replacing electrical water heating and various levels of market penetration. There was a reduction of between 0.10 to 0.31 million metric tons of CO2 production when a 64 ft^2 solar heater was used to offset the need for electric water heating.

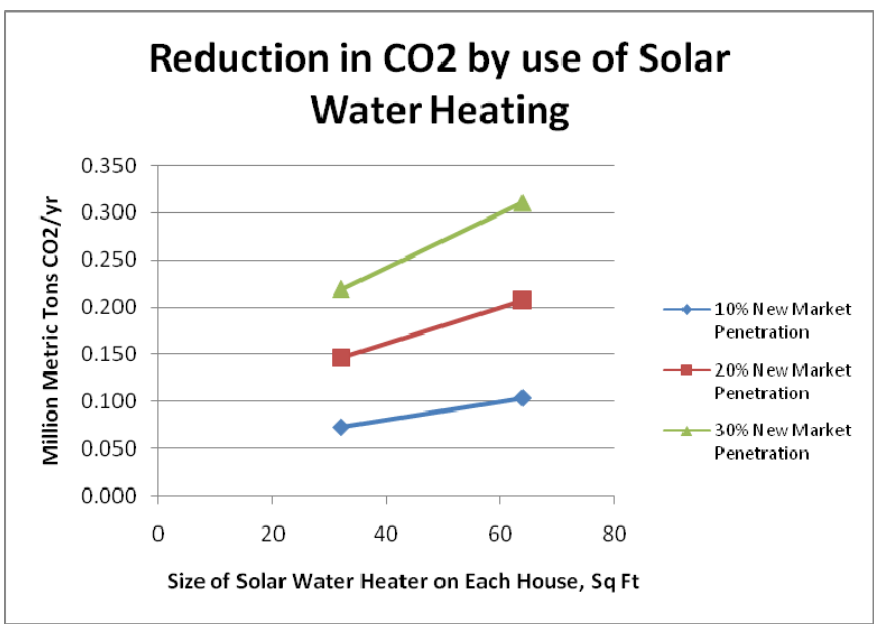


Figure 9b. Reduction in CO2 Produced Due to Using Solar Water Heating

The number of jobs created[36] would be approximately 840 new jobs if a 20% market penetration was assumed.

4.3 Solar Photovoltaics

The amount of energy saved by installing a solar photovoltaic (PV) system on new houses is presented in Figure 10a. The range of PV system sizes analyzed were 2 to 8 kW. The size of PV installed is typically based upon the amount of funding available; and these sizes still will not provide all the energy used in the house. The three lines are based upon the number of PV systems installed: 10-, 20-, or 30% of the estimated 388,191 new homes built between 2008 and 2025. This represents 38,819, 77,638, and 116,457 houses respectively for the 10-, 20- and 30% market penetration.

The range of site energy saved was between 0.32 and 0.96 tBtu/yr assuming 2 kW systems are installed and from 1.3 to 3.9 tBtu/yr for 8 kW systems. The summary of energy savings table assumes 6KW and 20% market penetration.

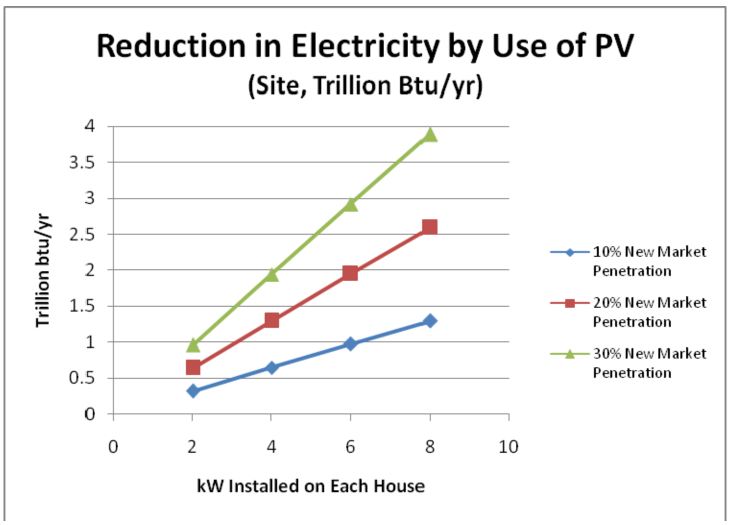


Figure 10a. Electrical Energy Savings by Using Residential PV Systems

The number of jobs created to install the 20% market penetration of photovoltaics would be approximately 1075 new jobs.

Residential PV systems also reduce the peak electrical demand when they are connected to the grid. The maximum electricity provided by the PV systems on the peak winter and peak summer day are presented in Figure 10b using 10-, 20-, and 30% of the new market penetration. The summer and winter peak generation are nearly the same but the winter generation is somewhat greater due to the higher PV efficiencies in the cooler temperatures. The range of electricity generated by installation of 2kW

[36] It is assumed that it would take 4 man-days to install a solar water heating system and 5 man-days to install a solar PV system.

systems is from 57 to 170 megaW and it is between 226 to 678 megaW for installation of 8kW PV systems.

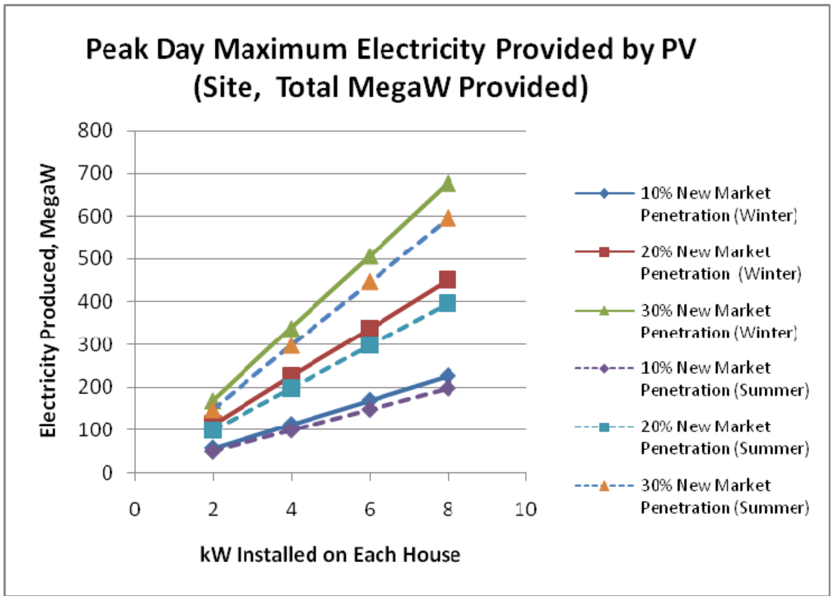


Figure 10b PV Electrical Generation on Peak Winter and Summer Day

Using PV systems to displace electrical energy also reduces the amount of CO_2 produced. This reduction is presented in Figure 10c for the 2 to 8 kW PV systems and various levels of market penetration. There was a reduction of between 0.10 to 0.31 million metric tons of CO_2 produced when 2 kW systems were used and between 0.42 and 1.26 when 8 kW systems were used.

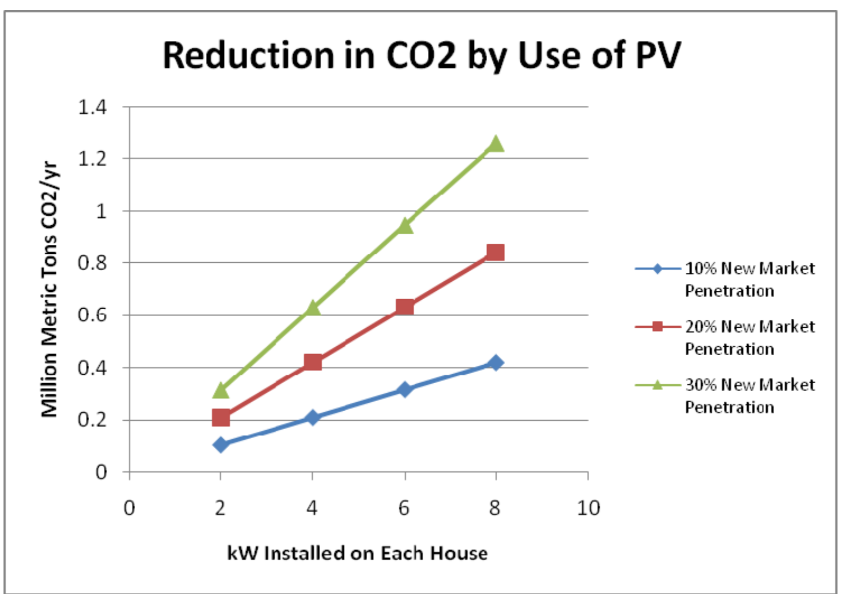


Figure 10c. Reduction in CO_2 Produced Due to Using Residential PV

4.4 Wind

Kentucky has relatively low wind resources compared to other parts of the nation and has received proportionately fewer wind survey assessments. The limited data available suggests that large utility-scale wind development is unlikely; however, certain areas of the state, local topographical features and new technology may be amenable to smaller distributed wind systems.

The Wind Energy Resource Atlas of the United States associates most areas of Kentucky with a class 1 or class 2 wind power designation[37]. Small areas of class 3 wind power are found along the mountain ridges in the extreme southeastern part of the state. A wind power class represents a range of wind power densities (W/m^2) that is likely to be encountered at an exposed site in the area. Wind turbine applications require class 3 or better wind power. Class 2 areas are considered marginal and class 1 areas are generally unsuitable.

Citing data from a 1991 study by the U.S. Department of Energy's Pacific Northwest National Laboratory, the American Wind Energy Association estimates that Kentucky has 49 km^2 of class 3+ areas that are not under land-use or environmental restrictions[38]. Developing these areas and accounting for the potential of small-wind systems, Kentucky is believed to have the capacity to generate 34 megawatts of wind energy power on average. Operating over the course of a year, this represents 1.0 tBtu of useable site energy. The equivalent source energy would be approximately 3.2 tBtu.

4.5 Methane from Landfills

The Environmental Protection Agency (EPA) maintains a database of landfill gas energy projects and candidate landfills[39]. According to the EPA, Kentucky has 6 active landfill-to-energy sites, 18 candidate sites and 12 sites that could have landfill-energy potential.

Of the six active landfill sites, five are used to generate electricity having a combined 16 megawatts of production capacity. The sixth, by far the largest landfill site in the state, provides 0.72 million cubic feet of gas per day to an industrial park for use in steam

[37] 1986. Elliott et. al. Wind Energy Resource Atlas of the United States. U.S. Department of Energy National Renewable Laboratory. Golden, CO. <http://rredc.nrel.gov/wind/pubs/atlas/titlepg.html>

[38] 2002. The American Wind Energy Association. An Inventory of State Incentives for the U.S.: A State by State Survey. AWEA, Washington, DC. <http://www.awea.org/policy/documents/inventory.PDF>

[39] 2008. Environmental Protection Agency. LMOP Project database. <http://www.epa.gov/lmop/proj/index.htm>

boilers – approximately half of the methane collected at the landfill[40]. The 18 candidate and 12 potential sites have a total of 53.4 million tons of waste in place.

Assuming that all of the methane at the largest landfill can be utilized and that the waste available for energy projects in the future will approximate the tonnage held currently, landfill methane recovery could provide 2.0 tBtu of site energy in 2025. The energy potential presented in Table 10 assumes methane contains 506 btu/ft^3 and that 1 million tons of waste in place is equivalent to 0.8 MW of electricity generating capacity.

Table 10. Landfill Energy Potential (tBtu/yr)

Landfill Sites	Utilization	2008	2025
5 active	Electricity	0.48 (16 MW)	0.48 (16 MW)
1 active	Direct	0.13 (0.72 million scfd)	0.27 (1.4 million scfd)
18 candidate + 12 potential	Electricity	0	1.3 (42.7 MW)
Total (Site)		0.6	2.0
Total (Source)[41]		1.7	5.9

4.6 Biopower from available forest resources – creating electricity

Kentucky has a large potential for producing woody material for renewable energy. Antares Group has estimated for KY a potential 4.18 million dry tons per year (mdt/yr) from forest thinning[42] (1.21 mdt/yr), forest residues[43] (1.95 mdt/yr), urban wood[44] (0.34 mdt/yr), and mill residues[45] (0.67 mdt/yr). Assuming an energy content of 8,000 btu/dry lb, the woody material identified by the Antares Group study could produce 66.9 tBtu/yr. This neglects the potential of utilizing CRP land and underutilized farm land for short rotation woody groups that would increase the potential for forest products.

[40] Personal communication. Louisville Air Pollution Control District.

[41] Source energy includes a 3.2:1 conversions factor for electricity.

[42] Antares assumed fuel removal projects are limited to only 85% of forest lands, 60% of North American forest land is accessible with conventional logging equipment, and a 30 year recovery cycle.

[43] Antares assumed conventional logging operations only allow for 60 to 65% of logging residues to be collected and land clearing projects only allow half of other removals to be recovered.

[44] Antares assumed only 38.9% of the wood was available for fuel production.

[45] Antares has assumed that only 35% of primary mill residues would be available for a biofuels project.

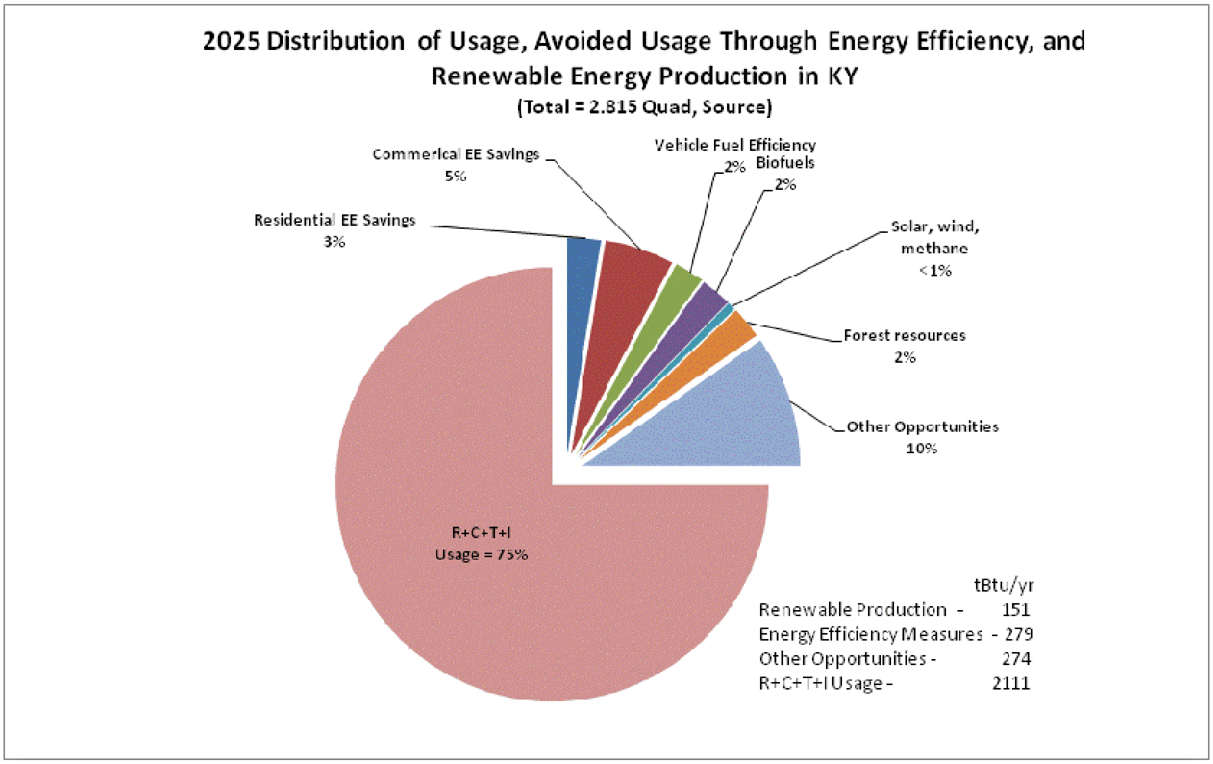
5.0 Summary of Energy Savings

Based upon the finding in the previous sections, the estimate of the energy savings potential for energy efficiency and renewable sources are summarized in Table 11. The total energy savings potential from renewable energy resources, biofuels and energy efficiency in the residential, commercial and transportation sectors in Kentucky amounts to approximately 15% of the total estimated source energy used in Kentucky in 2025. The industrial sector was not investigated in this analysis.

Table 11. Summary of Potential Source Energy Savings, tBtu

	2025 Energy Savings Potential, tBtu
Residential EE	70.7
Commercial EE	146
Light duty vehicle fuel economy	62
Biofuels	65.6
Residential Solar Water Heating .	2.0
Residential Photovoltaics	6.3
Wind	3.2
Landfill Methane	5.9
Forest Resources	66.9
Total	428.6

Figure 11. The potential source energy savings of energy efficiency and renewable energy items identified.



APPENDIX – CONVERSIONS

KY Fraction of Energy Use in the East South Central Region

	Site	Source
Residential	0.2555	0.2407
Commercial	0.2559	0.2418
Industrial	0.2611	0.2853
Transportation	0.2418	0.2418
All Sectors	0.2525	0.2589

Conversions

All masses are in dry (0% moisture) basis.

Ethanol assumed 70% of energy content of gasoline. All volumes of fuel reported as gallons of gasoline equivalent.

Available Land Resources

Crop production in each county estimated using the average of 2002-2006 data from USDA-NASS

Cellulosic ethanol from crop residues

Ethanol yield of 80 gal/ton

Sustainable removal rate of 1.0 and 1.5 ton/ac for corn and wheat stover.

Five year average of 1,097,000 acres of corn harvested

Ethanol from corn stover = 1.0 ton/ac*(1,097,000 ac)*(80 gal/ton)*(0.7 gal gas/gal ethanol) = 61,457,760 gal of gasoline equivalent

Switchgrass to ethanol

Ethanol yield of 80 gal/ton

Production rate of 8 ton/ac/yr

One quarter of other hay ground converted to switchgrass

Additional five percent of pasture land converted to hay production

Total switchgrass acreage of 564,000 ac

Ethanol from switchgrass = 6 ton/ac*(564,000 ac)*(80 gal/ton)*(0.7 gal gas/gal ethanol) = 252,672,000 gal of gasoline equivalent

Source to Site Electricity Conversion[46]

Source to site ratio = 1 + (Electrical system energy losses/retail electricity sales)

Ratio for KY = 3.20 (value used in this paper)

Residential = 3.197

Commercial = 3.198

Industrial = 3.196

Electricity produced on site avoids thermal generation and transmission losses.

1 Btu site energy = 3.2 Btu equivalent source energy.

Applies to electricity generated by wind, solar PV, and landfill methane.

It's assumed that solar hot water is displacing electrical water heating and therefore applies to solar water heating.

[46] http://www.eia.doe.gov/emeu/states/_seds.html

Kentucky Rural Energy Consortium

25x'25 Roadmap for Kentucky

Charting Kentucky's Renewable Energy Future