Hemp: An Energy Crop to Transform Kentucky and West Virginia

2014 Whitepaper

Presented By

KHGCA
Kentucky Hemp

WVHGCA
West Virginia Hemp

Biographical Sketch

The Kentucky Hemp Growers' Cooperative Association is a member-owned corporation providing assistance, information, and resources to partner-members endeavoring to produce or sell industrial hemp. Incorporated in 1994, the Cooperative seeks to uphold a tradition of legal and profitable hemp production in Kentucky. The original Kentucky hemp cooperative association was organized during WWII and produced high-quality industrial hemp for vital military stores, including oil, textiles, and cordage for naval vehicles and airplanes. The KHGCA is organized for agricultural purposes and to stimulate economic enrichment in the region.

A sister of KHGCA, the West Virginia Hemp Growers' Cooperative Association intends to expand the potential economic benefits of the hemp industry across the state. As an active member of the Central Appalachia Sustainable Economies (CASE) network, the cooperative seeks to ensure a resilient West Virginia economy by stimulating the emergence of dense industry clusters by way of Integrated Energy Park development.

About the Authors

Katherine M. Andrews, Ph.D., is a Ronin Institute Research Scholar working in the areas of Translational Science and Integrated Energy Systems (http://ronininstitute.org/research-scholars/katherine-andrews/). With a doctorate in biochemistry from the University of Illinois, she completed post-doctoral training in neuroscience and a faculty post in genetics, at Washington University in St. Louis, before moving to the private sector and taking on a series of cross-disciplinary leadership roles that bridged business and science, in fields ranging from computational drug design for the pharmaceutical industry to metabolic engineering of microbes for the production of biofuels. In 2007, she served as co-principal investigator to win a $135 million federal award that launched the DOE Joint Bioenergy Institute (Emeryville, CA), while managing Sandia National Laboratories' Department of Computational Biology. Now based in the Bluegrass Region of Kentucky, she is an executive level strategist who works with all sectors to redefine business models, attract investors, and optimize research and development programs based on both technical and market knowledge.

Alex Donesky is currently a student at Wesleyan University in Middletown, Connecticut where he studies Economics, History and Government. He served as a 2013 Intern with Patriot Bioenergy Corporation and with Sustainable Williamson, studying renewable and biomass energy projects and the development of sustainable methods and technologies.

Roger Ford is an entrepreneur with over 25 years of experience in governmental relations, political strategy, and economic and business development. He is CEO of Patriot Bioenergy Corporation and a partner in Emergy Holdings, Inc. and TerraGas, LLC. He graduated from The University of Pikeville and is working to complete his Masters in National Security at American Military University. Ford is a member of the Southern States Energy Board's Clean Coal and Energy Technology Collaboration Committee, the Board of Directors for the Kentucky Hemp Growers' Cooperative Association, the Board of Directors of the West Virginia Hemp Growers' Cooperative Association, and the Chairman of Sustainable Pike County and Sustainable Williamson, which are both part of the Central Appalachian Sustainable Economies (CASE) Network.

J. Eric Mathis has been at the forefront of initiatives to bridge the gap between the fossil fuel and renewable energy industries through the development and implementation of innovative finance and business models. These models are designed to be beneficial to both industries, creating mutually productive economic linkages between the fossil fuel and renewable industries, and most importantly between the surrounding communities. As an active member of the community, he is helping to develop a comprehensive project entitled Sustainable Williamson that emphasizes health and wellness as a key component for economic revitalization. Using Sustainable Williamson as a template, his most recent endeavor is participating in the creation and implementation of the Central Appalachian Sustainable Economies (CASE) network, an interactive regional network of innovators cultivating new ideas and resources in central Appalachia to grow healthy communities.

White Paper – Hemp: An Energy Crop to Transform Kentucky and West Virginia

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Executive Summary

Industrial hemp (*Cannabis sativa L.*) has been grown and evaluated for energy purposes in the United States, Ireland, Spain, Germany, Poland, Sweden, and many other countries[1]. A proven Kentucky crop possessing favorable characteristics of high land use efficiency, low requirement for pesticides, and high drought tolerance, hemp offers to comprehensive solution to its current economic and energy challenges. In 2013, the Kentucky Legislature signed Senate Bill 50 (SB50) into law, opening the door for a regulatory framework to be established for farmers to become licensed to grow hemp. Twenty other states have passed similar hemp legislation to re-introduce industrial hemp as an agricultural crop for harvest and manufacturing of diverse products, including oil, structural fiber, and materials. We suggest that hemp is a viable biomass feedstock for the production of fuels, industrial chemicals, advanced materials, and electricity in Kentucky and neighboring states such as West Virginia. Here, we present the results of a preliminary study performed by Patriot Bioenergy Corporation, in collaboration with the Kentucky Hemp Growers Cooperative Association and West Virginia Hemp Growers Association, to assess the technical feasibility of co-firing of hemp with coal for power generation. We suggest that the accelerated adoption of hemp to grow the increasingly intertwined energy, agricultural and manufacturing sectors will particularly benefit rural regions.

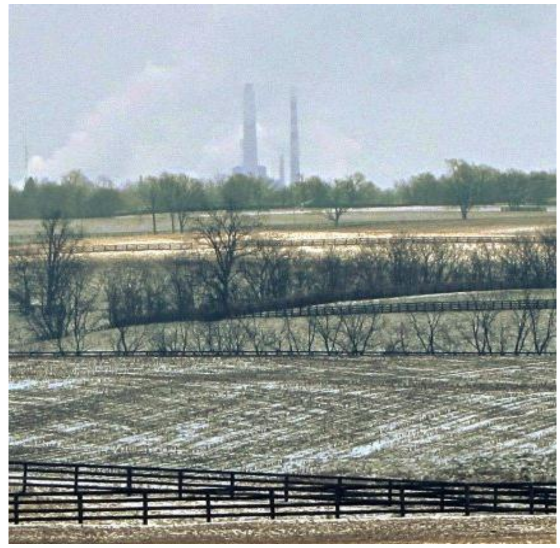
Biomass co-firing is an attractive near term strategy for existing power plants to achieve reduction of carbon dioxide and other pollutants in compliance with new regulations on emissions.

The Energy Challenge

Major technological and commercial hurdles must be overcome in order to strengthen the struggling economies of Kentucky and West Virginia, in a rapidly changing energy landscape in which fossil-derived energy sources are being replaced by renewables. Notably, the use of coal-fired generators has dramatically declined in the Southeast, with the region experiencing the largest shift from coal to natural gas in the United States from 2011 to 2013[2]. As top energy exporters, these states have relied historically on coal as the predominant feedstock for electricity generation to fill local power needs, and for export to other states and the international markets[3,4].

New regulations and policies have reduced the demand for coal, and plants are closing due to a lack of cost effective ways to reduce emissions, particular sulfur and mercury[5]. As a result, regions of the states where coal is mined and converted in power plants are suffering from job losses and an uncertain future. In order to compete nationally and internationally, we must undertake an 'all-of-the-above' strategy for energy production and export that includes renewables and biomass and supports growth of the economy in rural Kentucky and and West Virginia.

Along with global competition from other energy resources such as natural gas, the coal power industry also faces new regulatory mandates and public policies[6] that require adaptation by the industry to ensure that coal remains viable. Despite higher heat values than Western coal, Appalachian coal is particularly at risk due to its mining costs, sulfur content, and heavy metal composition. Coal mined from the Illinois and Appalachian Coal Basins would benefit from the blending with biomass.



Power facilities such as the E.W. Brown Generating Station in Central Kentucky, are optimally co-located with thousands of acres of land suitable for hemp cultivation.

Photo: K. Andrews © 2010

By blending coal with biomass materials such as hemp, sulfur emissions from power generation can be reduced and less valuable coal that is high in sulfur can remain competitive. While significant public and private investments around the nation have accelerated the development of biomass energy crops and processes for transportation fuels, chemicals, and electricity, no major biomass crops have been adopted in Kentucky to date. State-funded research centers have prioritized combustion and carbon sequestration over biofuels[7]; and although the U.S. Department of Energy has named I-65 'the nation's first biofuels corridor[8,9], only one ethanol plant[10] and one biodiesel[11] plant currently operate in Kentucky at a commercial scale. There are currently no publicly announced plans for second generation "cellulosic" fuel production, made possible through intense research and engineering in the past five years[12,13,14,15]. West Virginia passed SB447 in 2002 and helped to establish early guidelines for hemp production in the United States. The 2013 signing of Kentucky's SB50 into law further enables the potential of hemp as an energy crop to be realized throughout the region and accelerated by integration with existing energy production practices.

Hemp: A Biomass Energy Crop

Industrial hemp has been studied extensively by researchers at national laboratories, universities, and leading international research institutions, for its potential as a bioenergy crop[16,17,18,19,20,21]. Biomass crops have been prioritized by the United States Departments of Energy (DOE) and Agriculture (USDA)[22] for development across the nation due to their great potential for increasing the share of domestic renewable energy. Hemp biomass is routinely included in comprehensive biomass evaluations for specific industrial applications[23,24,25,26], and hemp's molecular structure and chemistry have now been characterized for a variety of purposes[27,28,29,30]. A multitude of recent publications in science and engineering journals have reported the successful conversion of hemp to transportation fuels, chemicals, biodegradable polymers, and a broad range of advanced materials[31,32,33,34,35,36,37,38,39,40,41,42]. Exciting new developments include the use of exfoliated hemp to produce high capacitance graphene nano-sheets for use in large-scale production of energy storage devices[43].

While few annual crops can easily be rotated with food and feed crops – a critical parameter for sustainable energy production - crops for which the whole plant biomass can be harvested and used for energy production can result in high land use efficiency. Detailed life cycle analyses[44,45], agronomic studies[46,47,48,49,50], environmental impact evaluations[51,52,53], and techno-economic assessments[54,55] of hemp under a variety of conditions indicate that industrial hemp is viable for accelerated development and integration[56] at the commercial scale for multiple industrial applications.

Refined biomass for co-firing and power generation

Now demonstrated at more than 150 power-generating sites around the globe[57], biomass co-firing is attractive as a viable near term strategy for existing power plants to adopt in order to achieve reduced emissions of carbon dioxide, sulfur and other pollutants in compliance with new regulations on emissions. Co-firing has the advantages of lowered pollutant emissions, improved carbon footprint due to the consumption of CO_2 by biomass crops, low capital costs as an add-on, and fuel flexibility to accommodate a range of usable biomass fuels depending on regional, seasonal, and weather factors[58].

Scientists at the National Renewable Energy Laboratory (NREL) in Golden, Colorado, have evaluated co-firing in all types of boilers used by electric utilities and demonstrated that boiler efficiency is not lost when co-firing biomass blends[59]. Refining of biomass by torrefaction[60], steam explosion[61,62,63], hydrothermal carbonization[64,65,66,67], and other methods increases the energy density of biomass and yields a more coal-like, hydrophobic consistency along with improved storage and handling[68]. As for fossil fuels, the key characteristics of biomass fuels are the thermal capacity along with physical, chemical, and combustion properties. Refined biomass to be used for combustion must be characterized for properties such as total ash content, melting behavior, chemical composition, and heat value. Here, we present the results of a preliminary technical feasibility study of hemp combustion, performed in parallel with higher sulfur coal that is typical of Appalachian and Illinois coals.

Technical Feasibility

A representative coal sample from the Illinois Coal Basin was obtained for determination of cogeneration thermal capacity and to determine the level of emissions reductions due to blending coal with hemp biomass. Analyses were done according to recognized global standards[69]. As is typical of coal from Appalachia with sulfur content of 3.45%, the coal was used to prepare a series of blended samples for combustion analysis. Testing of a series of co-blended samples was done to understand the impact of increasing the ratio of hemp to coal on energy yield and sulfur emissions. The results are shown in Figure 1 below.

Combustion of the hemp sample yielded 0.10 percent sulfur and 9533 BTU, thus hemp emits only 0.105 pounds of sulfur per million BTUs produced. By comparison, combustion of the coal sample yielded 3.45 percent sulfur and 13210 BTU generated per pound, thus the coal sample emits roughly 2.6 pounds of sulfur per million BTUs produced, well above the levels set by new regulatory standards. A fifty percent blend of dry hemp hurds and coal will reduce the sulfur emissions of the plant to 1.56 pounds of sulfur per million BTUs - a reduction of forty percent - still above new federal levels but within reach of scrubbing technology available today[70].

Our results show that hemp biomass is a promising feedstock for power co-generation, a notion supported by recent engineering and techno-economic studies[71,72]. The introduction of industrial hemp as a biomass energy feedstock can improve the economics of co-firing due to adaptability, high per-acre yield, and potential to be grown on post-mining land and reclamation sites.

Conclusions and Recommendations

There is now a solid body of evidence supporting the use of hemp as a feedstock for energy production as well as manufacturing. Research efforts must therefore shift from proof-of-concept and characterization performed in academic and government laboratories around the world to applied science and engineering associated with private sector deployment and commercialization of technology. Our vision is that existing power plants will serve as hubs for integration of agriculture, energy conversion, and manufacturing in a new economy that benefits from the ability to convert biomass, and particularly hemp, into thousands of valuable products[73]. Favorable economics will be achieved through highly integrated sets of conversion technologies that utilize regionally available biomass and manufacture diverse products ranging from liquid fuel and biogas to fertilizer and animal feed. Research on new technology can be accelerated and engineering will be informed by interfacing with mature processes, such that economic and environmental benefits can be realized. Life cycle analysis and techno-economic assessment of specific engineering applications of hemp-based manufacturing, fuel production, and power generation must now be used on a case by case basis to provide necessary knowledge to aid in decision-making for farmers, researchers, and manufacturers, and investors. Agricultural economic models also provide insights on the expected returns of hemp to compare with expected returns of currently produced crops in the area, and help to identify feedstock issues and project costs and market options for hemp as a biomass crop. These evaluations are routinely undertaken by companies to inform the engineering of physical plant operations, and are anticipated by both the KHGCA and WVHGCA as critical steps in the business development pipeline for the hemp industry in Kentucky and West Virginia.

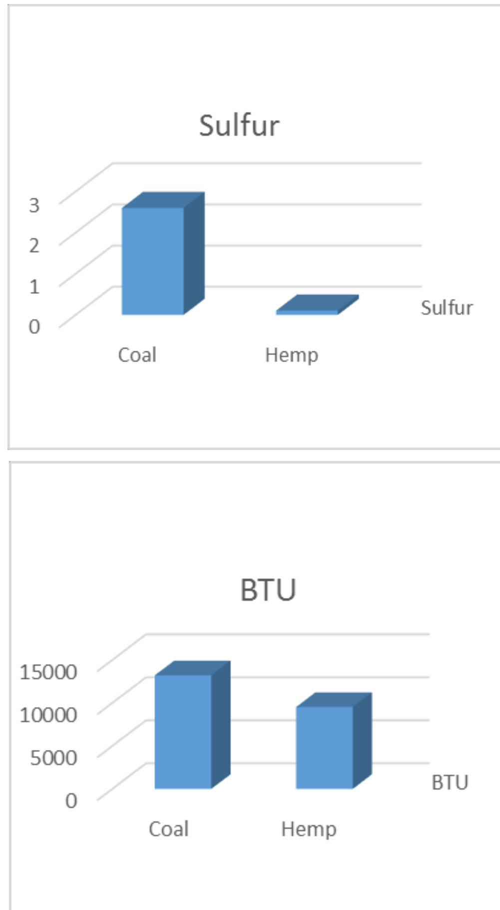


Figure 1. Comparison of energy content (BTU) and sulfur emissions (lb sulfur/million BTU) obtained for test samples.

To stimulate the hemp economy, we recommend that policy makers take the following actions to move forward decisively:

- Prioritize, as a matter of urgency, applied research and development in the form of integrated energy demonstration projects across the region, and develop expertise in life cycle analysis and techno-economic assessments of new energy production and manufacturing processes.

- Provide economic incentives to attract new businesses to the region for biomass processing, manufacturing of fuels, chemicals, and materials from hemp.
- Accelerate the re-development of hemp farming, processing, and manufacturing by creating Ag-Tech hubs for the translation of science and engineering to practice. Shared facilities would allow growers and researchers to rapidly produce seed stocks and develop new strains optimized for energy production, and to provide space and physical resources that enable local outreach and encourage entrepreneurship.
- Support the formation of a regional private-public consortium to create a *Roadmap for Hemp-Based Manufacturing and Energy Production in Rural Kentucky and Central Appalachia*, to serve as a clear path for federal policy makers and funding agencies such as the Departments of Energy (DOE) and Agriculture (USDA) to follow.

"The energy sector must continuously adapt and use viable technologies that are best for Kentucky, West Virginia and our nation. The war on coal has taken its toll. We need to save and create jobs in Kentucky and West Virginia. This white paper poses an adaptive solution. Hemp is indeed a viable option."

- *David Hadland, President of KHGCA*

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