SIU SOUTHERN ILLINOIS UNIVERSITY CARBONDALE ADVANCED ENERGY INSTITUTE

Southern Illinois' Energy Future And the Role of SIU

February 2015

Executive Summary

Energy is a crucial consideration for the continuing health and prosperity of humans on this planet. Many urban areas and communities are making bold plans to embrace the challenges and optimize potential outcomes for their constituents in the long run. While many opportunities exist for the prosperity of the region, energy plays an important role in any strategic plan. What's the plan for southern Illinois, and how can local individuals and organizations benefit? This paper aims to provide a current snapshot of energy policy and industry in southern Illinois, ponder the potential of the region's energy future through innovative research and community initiatives, and propose next steps towards a healthy, prosperous energy future. As a key economic engine of the region, Southern Illinois University (SIU) and its Advanced Energy Institute (AEI) have important roles to play in this process.

About Southern Illinois University (SIU)

SIU (www.siu.edu) embraces a unique tradition of access and opportunity, inclusive excellence, innovation in research and creativity, and outstanding teaching focused on nurturing student success. As a nationally ranked public research university and regional economic catalyst, we create and exchange knowledge to shape future leaders, improve our communities, and transform lives.

About the Advanced Energy Institute (AEI)

The mission of AEI (www.energy.siu.edu) is to:

- Assist faculty, students and others in the campus research community in engaging in advanced coal and energy-related research and service opportunities, and
- Advocate and initiate activities that advance the university as a leader in interdisciplinary advanced coal and energy research, education and service to the ultimate benefit of society and the environment.

Disclaimer

This paper is meant to provide a broad overview of the topic and spur discussion about this particular moment in time, rather than serve as a scientific or educational reference. While as factual and referenced as possible, we recognize the possibility of errors or omissions and encourage feedback to energy@siu.edu.

Contents

Introduction

Energy is a crucial component of growth in societies, since the dawn of time. Nowadays when we talk about "growth," we can no longer talk about the endless resources and limitless potential for material wealth; the impact of growth has become too large to ignore. Instead, we can talk about a world where we can optimize resource use while minimizing impact on the environment so that people can live, work and grow to achieve comfort and prosperity.

Clean, efficient energy is a mixed bag of challenges, especially where traditional sources of energy, i.e. fossil fuels, are concerned. In 2009, Illinois and our closest (southern Illinois) neighbors Kentucky and Missouri reported an energy generation mix[12,2] with a majority coming from coal. By 2013 in Illinois nuclear has overtaken coal as the leader, but coal remains king in Missouri and Kentucky, and Illinois is #2 in the nation for coal reserves.[34] So clearly, knowing how to use it more cleanly and efficiently is a benefit to our region. Fossil fuels, including coal, have provided abundant, safe and reliable energy for many years, and are likely to continue to do so in some capacity. Using coal where applicable as part of a diversified/distributed/regional energy mix to increase grid flexibility will likely provide sizable benefits that will entrench it as a key player. Mining safety and health of miners can be prioritized, and cleaner ways of using the resources can be employed while waste such as carbon dioxide can be recycled for value. These are some of the challenges AEI helps to untangle.

Other sources of energy also provide challenges to overcome. Even the most promising renewable energy resources deliver varying degrees of impact, resource use and industrial activity.[5] With 26 million acres of farmland, Illinois is a top producer of ethanol;[67] the bioeconomy, where petroleum based products are replaced by renewable feedstocks, is coming online but will still have energy needs, waste and environmental impact. While something like passive solar and building efficiency could have a huge impact on energy use and costs, a shift in attitudes and building codes would be required. Illinois households use[8] 44% more energy than the national average, but only spend 2% more on electricity bills; clearly there's room for

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[1] "eGrid2012 Version 1.0, Year 2009 Summary Tables." United States Environmental Protection Agency.
[2] .
http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2012V1_0_year09_SummaryTables.pdf [2] All web links last accessed February 25, 2015.
[3] "Illinois State Energy Profile." United States Energy Information Association. Last updated March 27,
[4] . http://www.eia.gov/state/?sid=IL
[5] Zehner, O. (2012). *Green illusions: the dirty secrets of clean energy and the future of environmentalism*. U of Nebraska Press.
[6] "Illinois State Energy Profile." United States Energy Information Association. Last updated March 27,
[7] . http://www.eia.gov/state/?sid=IL
[8] "Illinois State Energy Profile." United States Energy Information Association. Last updated March 27, 2014. http://www.eia.gov/state/?sid=IL

improvement here, but how? Every scenario has complex challenges that need to be realistically and factually worked out. AEI, with its access to top-tier researchers in many areas, covers a broad realm of expertise to assist organizations, individuals and communities in identifying and filling the gaps to fortify the path ahead.

While we may not know exactly how the end product ("future of energy in southern Illinois") will look, the end goal should be transparent and common-sense solutions that are accountable to all stakeholders. We should be able to leave a trail so that future generations can learn from our experiences. Corporations and individuals should be able to profit, while serving to benefit the entire system that is enabling the profit to occur. People are more informed, they are demanding truth and responsibility and corporate concerns and governments are responding. Many companies,[7] nations[8] and even investors[9] are taking steps to increase the percentage of their portfolio that includes clean and/or renewable energy. Currently, market analysts for fossil fuels are bearish,[10] while fossil fuels are being equated with tobacco companies.[11] California is shooting for 50% renewables by 2030.[12] The Solutions Project, aiming for 100% renewables by 2050, calls for wind, solar, and water (including tidal turbines and offshore wind) power for Illinois.[13]

Even assuming we can reach 100% renewables, 2050 is more than three decades away. How do we get there? What is the optimal path for southern Illinois individuals and organizations? Obviously, this could be a long journey. With a long history in the community, a worldwide acknowledgement as a center of expertise for research and education, and a wealth of ideas and creativity, SIU and AEI can play important roles in untangling the mass of complications. This white paper aims to start that process by laying out the pieces of the puzzle. First we look at the current status of energy policy and industry as it pertains to southern Illinois. Next, we look at the future through energy research at SIU and innovative initiatives that are helping other communities. Finally, we set a simple common-sense course to begin the journey.

[7] "Top 10 Green Companies in the World." Newsweek. http://www.newsweek.com/green/top-10-greencompanies-world

[8] "Top 10 Countries Investing in Clean Energy." UPI.http://www.upi.com/News_Photos/Features/Top-10countries-investing-in-clean-energy/fp/3200/

[9] "Expect $1.6 Trillion in Clean Energy Investments Through 2020, Says IEA." Renewable Energy World. August 28, 2014. http://www.renewableenergyworld.com/rea/news/article/2014/08/expect-1-6-trillion-inclean-energy-investments-through-2020-says-iea

[10] Campos, Rodrigo. "Exclusive: Sell-side Sours on U.S. Energy Stocks More than Any Sector." Reuters. Thomson Reuters, January 6, 2015. http://www.reuters.com/article/2015/01/06/us-usa-energy-earningsidUSKBN0KF1KX20150106

[11] "Climate Change Groups Split on Fossil Fuel Divestment - FT.com." Financial Times. http://www.ft.com/cms/s/2/5ca02a4c-8792-11e4-bc7c00144feabdc0.html?segid=0100320#axzz3O9NUYGZm [12] Ayre, James. "California's Governor: 50% Of Electricity From Renewables By 2030." Cleantechnica. January 6, 2015. http://cleantechnica.com/2015/01/06/californias-governor-50-electricity-renewables2030/?utm_source=Cleantechnica+News&utm_medium=email&utm_campaign=e4cf6dc9f9-

RSS_EMAIL_CAMPAIGN&utm_term=0_b9b83ee7eb-e4cf6dc9f9-331977021

[13] "50 States, 50 Plans." The Solutions Project. http://thesolutionsproject.org/infographic/#il

Illinois Energy Profile

Policies and Incentives

Here we provide a broad overview of some energy-related policies and incentives having an impact on the southern Illinois region.

Renewable Portfolio Standards (RPS)

The Database of State Incentives for Renewables and Efficiency (DSIRE)[14] provides a list of Illinois financial incentives, policies/rules and programs available. DSIRE only includes especially innovative efforts, or to heavily populated localities, so may not provide a complete picture, but still serves a purpose.

The Illinois RPS is to achieve 25% renewables by 2025. Eligible renewable/other technologies include: Solar Thermal Electric, Photovoltaics, Landfill Gas, Wind, Biomass, Hydroelectric, Anaerobic Digestion, and Biodiesel. Most (60-75%) of the portfolio's renewable percentage will come from wind; how does southern Illinois factor in? Most studies, including that by the Illinois State Water Survey,[15] show that southern Illinois is not optimal for wind power, due to lower wind speeds. Six percent is mandated for solar (1.5% of electricity), which bodes better for southern Illinois. Of the 29 U.S. states with renewable portfolio standards in place, four of them include clean-coal and/or CCS technologies in their list of eligible renewable technologies, according to DSIRE; in these cases it seems that "low-carbon" has replaced "renewable."

It's unclear how impactful this RPS is for southern Illinois. AEI took up the discussion with local electric cooperative representatives recently. Due to the lack of a wind resource locally, southern Illinois must purchase wind-generated capacity from up north. The lack of regularity, lack of energy storage options and extra costs of transmission add to the complexity. While coal and nuclear power can be standing by to provide extra load, these plants work best at 100%, so again efficiency is lost if they're running at uneven loads. Further, recent developments saw Ameren, the biggest commercial provider in southern Illinois, sell their power plants to Dynegy, so that they now have no generation in the state of Illinois. Ameren customers can now buy their electricity from smaller providers who may or may not be subject to the RPS. Recently, some local power cooperatives have been initiating and promoting grassroots advocacy against new EPA regulations that they say would increase electricity prices for consumers, even though the cooperatives themselves are not subject to the RPS. Over a million

[14] United States Department of Energy. "Illinois Incentives/Policies for Renewables & Efficiency." Database of State Incentives for Renewables and Electricity. http://dsireusa.org/incentives/index.cfm?re=0&ee=0&spv=0&st=0&srp=1&state=IL

[15] "Illinois State Water Survey - University of Illinois at Urbana-Champaign." Average Wind Speeds in Illinois, Illinois State Climatologist Office, Illinois State Water Survey, U of I. http://www.isws.illinois.edu/atmos/statecli/wind/wind.htm

Consumers petitioned their lawmakers; while it's probable that most people want to improve the environment, they don't want to pay more for electricity.

Some states are surpassing the RPS, based on Energy Information Association[16] data. The EIA does not expect that RPS will be the sole reason for the expansion of renewable generation, especially as RPS requirements will expire and renewable generation will become more competitive. Along the same lines, reduction of pollution from power plants has already resulted in billions in healthcare cost reduction; reduction of carbon dioxide can increasingly become an asset for energy producers through re-use in enhanced oil recovery or chemical production. Regulations have helped to spur the healthcare cost reductions; carbon dioxide reductions have good potential to be spurred by corporate opportunity.

Coal

Much has been written about Illinois coal policy and the effects of the Clean Air act on Illinois high-sulfur coal are well known. Illinois has served as a battleground regarding coal, and while it's impossible to please everyone all the time, it seems that coal policy in Illinois usually pleases no one. As a simplified illustration: one report[17] may discuss the harm to the Illinois industry, jobs and individuals because of tougher regulation, while another report[18] discusses the negative financial impact of the coal industry on the state's budget, calling for increased taxes and regulation of the industry. As mentioned previously, one thing everyone can probably agree on is that electricity needs to be affordable.

Carbon Tax

Many in the literature have spoken of the potential benefits of increasing the effectiveness of RPS in combination with a carbon price.[19] Many others deride anything resembling a tax as an economy and job killer. The battle rages on in Illinois, with Exelon claiming foul against the wind industry's preferred status in the Illinois renewable portfolio standard. Recent news[20] reports

[16] Bredehoeft, Gwen, and Michelle Bowman. "State renewable energy requirements and goals: update through 2013." Energy Information Association, April 30, 2014. http://www.eia.gov/forecasts/aeo/state_renewable.cfm [17] "The Illinois Coal Industry." Illinois DCEO, 2008. https://www.illinois.gov/dceo/AboutDCEO/ReportsRequiredByStatute/TheIllinoisCoalIndustryJune2008.pdf

[18] McIlmoil, Rory, Meghan Betcher and Amanda Kass. "The Impact of Coal on the Illinois State Budget, FY2011." 2013. Downstream Strategies and the Center on Tax and Budget Accountability. http://www.downstreamstrategies.com/documents/reports_publication/downstreamstrategies_illinois_impact_of_coal_6-27-13.pdf

[19] Carley, S. (2011). The era of state energy policy innovation: A review of policy instruments. Review of Policy Research, 28(3), 265-294.

[20] "Illinois Considering Carbon Tax, Cap-and-Trade to Save Exelon Nukes." January 12, 2015. http://www.rtoinsider.com/illinois-exelon-nuclear-12297/

that several Illinois agencies put forth a report for state legislators listing the following options, all of which would most likely result in some level of electricity price increases for consumers (list compiled by RTO Insiders):

- Do nothing, and rely "purely on the market and external initiatives to make corrections;"
- Establish a cap-and-trade program with other states, which would monetize the carbonfree nature of nuclear generation;
- Tax those generators that do burn fossil fuels and produce carbon emissions; ● Adopt a low-carbon portfolio standard; or ● Adopt a sustainable power planning standard.

Community Choice Aggregation (CCA)

Other initiatives are enabling communities to choose their energy providers. The CCA was passed in Illinois in 2009 enables cities and localities to pool their buying power in order to align with their energy goals (i.e. more use of renewables) while providing better rates. In 2013 in Carbondale and other communities across Illinois, "community choice aggregation" plans have been implemented that provide 100% renewable energy to citizens. The prices offered are comparable to the base price offered by Ameren because of aggregation among several communities, including Marion and West Frankfort. According to the World Wildlife Federation, this scenario has increased demand for renewable by 6 terawatt hours, "reducing pollution levels equivalent to taking more than 1 million cars off the road or 250,000 homes off the grid.

According to city and electric cooperative representatives, due to the fact that electricity is a real-time commodity, and that southern Illinois has insufficient renewable capacity to supply 100% renewable in practice, the CCA amounts to paying a little bit extra on renewable energy credits in order to vocally state that they provide renewable energy to their citizens. In practice the energy is produced locally and is approximately 70% coal-based in the southern Illinois region. CCA does provide communities such as Carbondale with opportunities for lower rates and to support renewable energy by buying credits.

Other Illinois Programs

In 2006, then Lieutenant Governor Pat Quinn was promoting the "All American Energy Plan" for Illinois that included investment in ethanol production, E-85 pumps at gas stations, renewable energy sources and energy conservation, coal gasification plants, and a carbon dioxide pipeline. While many of the aims of the program have progressed (13 ethanol plants are located in Illinois, and hundreds of E-85 pumps), the latter half of the list of goals have fallen by the wayside.

The Illinois Renewable Energy Resources Program was established to provide grant funds for solar and renewable energy projects. However, this program is not always properly funded. Net metering standards and good interconnection standards also bode well for Illinois clean energy development. The Illinois DCEO, USDA, and organizations such the Illinois Clean Energy Community Foundation offer grants and loan guarantee programs for a variety of project types.

Employment

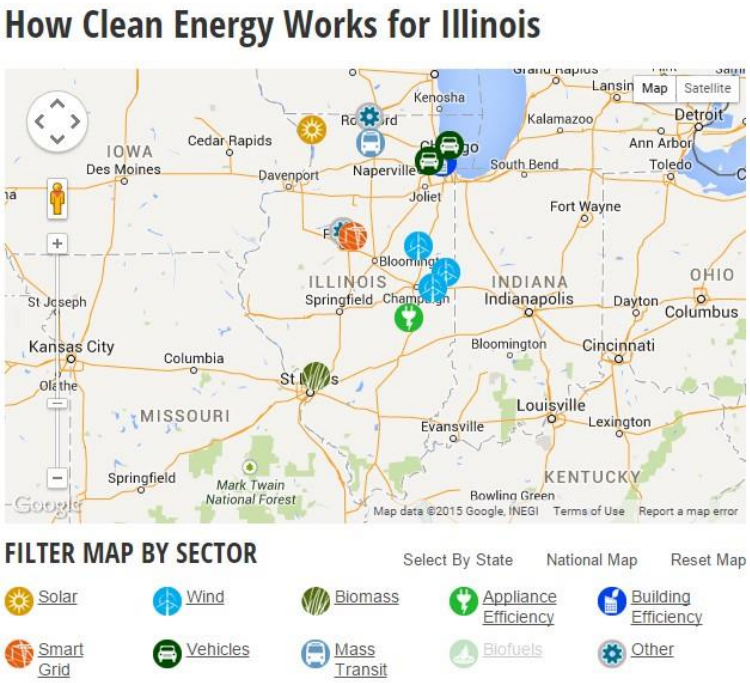
A quick scan of some Bureau of Economic Analysis[21] statistics provides some basic information about employment in southern Illinois versus the rest of the state. The big take-away: things are different down south. Regional employment data for the years 2009-2013 for the southernmost eleven counties (Southern 11) in Illinois was downloaded (Alexander, Hardin, Gallatin, Jackson, Johnson, Massac, Pope, Pulaski, Saline, Union, and Williamson). For the sake of this simple illustration, omissions due to proprietary withholdings or lack of data were counted as zero, which accounts for a small percentage (less than 5% in most cases) of each individual county's data. But just to get a bird's-eye view on the major differences:

- A good percentage of jobs (>20%) in the Southern 11 are from state and local government (due in large part, undoubtedly, to SIU's presence in Jackson County). Statewide this percentage is about half of what it is in the Southern 11.
- Farm employment in the Southern 11 is about three times that of the statewide average.
- Total number of employed in the Southern 11 is about 1.55% of the total employed statewide.
- The percentage of mining jobs is about five times as high in the Southern 11 as statewide (although it's impossible to know exact numbers since many of these numbers are not reported by companies).
- In the counties reporting the highest employment numbers (Jackson, Williamson), 2% or less is farm employment.
- The Southern 11 has about half as many working in manufacturing, and a slight amount more in retail than statewide

A recent study entitled "Clean Jobs Illinois"[22] reported that Illinois would surpass 100,000 clean jobs in 2014, with the majority of jobs involved with energy efficiency. But it's unclear of the benefit to southern Illinois. As this graphic shows, no jobs are reported in southern Illinois.

[21] US Department of Commerce, Bureau of Economic Analysis. http://www.bea.gov/

[22] "Clean Jobs Illinois." Clean Energy Trust. http://cleanjobsillinois.com/#welcome



Source: http://cleanenergyworksforus.org/states/illinois/

While this doesn't mean we shouldn't be looking to develop clean technology jobs in southern Illinois, it's clear that we will have to work harder to figure out how the southern region can benefit.

Industry

Southern Illinois has a unique and very different profile than much of the rest of the state, and we need to find out how to make the region's assets work toward the benefit of moving people forward.

Agriculture

According to the Illinois Department of Agriculture, marketing of Illinois agricultural commodities generates $19 billion in annual sales;[23] this doesn't include economic activity from related business or services such as equipment sales and mechanics. A study by the University of Illinois in 2007[24] found that 65% of the land in the southernmost 20 counties was used for

[23] "Facts about Illinois Agriculture." Illinois Dept. of Agriculture. 2014. http://www.agr.state.il.us/factsabout-illinois-agriculture/

[24] Flint, Courtney and Stephen P. Gasteyer. "Southern Illinois Regional Assessment - Executive Summary." University of Illinois at Urbana-Champaign, 2006.

http://research.aces.illinois.edu/sites/research.aces.illinois.edu/files/SIRAP/final/ExecutiveSummary.pdf farming, and a study by a food group[25] found that 39% of the farms in those counties reported losses in 2007, with much of the inputs sourced from outside the region. The University of Illinois study highlighted something of a consensus among various stakeholders in southern Illinois (farmers, forest owners, government, etc.) to highlight biofuels, specialty agriculture and better use of the vast natural resources of the region, including land use for hunting and recreation. They also recommended establishing a multidisciplinary research agenda driven by an advisory committee of regional stakeholders to address the wide variety of needs and opportunities, and stress the importance of the region's watersheds.

Forestry

In 2012, a study by the Illinois Forestry Development Council[26] valued forestry and forest products industry in the state at $23 billion. About 15% of the state of Illinois is forested, with the largest areas in southern Illinois, mainly in the Shawnee National Forest. Distribution of biomass is similar; in a 2010 study[27] the Illinois Department of Natural Resources (IDNR) suggests several strategies for improving the health and productivity of Illinois forests in order to provide economic resources for mainly private forest owners. According to the report, about 77% is privately owned, and only about 4% have forest management plans in place, which leaves open a big opportunity for forest management and wood products.

Gas and Oil

A 19-county area in southeastern Illinois[28] has been identified as most favorable for shale gas development, with one estimate showing economic impact of $9.5 billion. However environmental and regulatory uncertainty has stalled development. Meanwhile, media reports on the jobs lost in southern Illinois[29] because of the stalling of the IDNR in regards to fracking regulations. Job opportunities would include "drilling, equipment-making, road-building, fencing, trucking... Even the coffee shops and restaurants could gain a bigger lunch crowd." Other reports[30] highlight damage to the environment or increasing traffic accidents due to increased shale gas development.

[25] Meter, Ken. "The role of local food in economic recovery in southern Illinois." Crossroads Resource Center. June 2012. http://www.crcworks.org/crcppts/ilsouth12.pdf

[26] "Forestry and Forest Products." Illinois Forestry Development Council. 2011. http://new.ifdc.nres.illinois.edu/wp-content/uploads/2013/10/sm-il-forest-products-industry_2012.pdf

[27] "Illinois Statewide Forest Resource Assessments and Strategies." Illinois Department of Natural Resources. 2008. http://www.stateforesters.org/files/IL-Assess-Strategy-20100528.pdf

[28] Bieneman, Dave. "The Fracking Industry and Its Potential Impact on the Illinois Economy." Illinois Department of Employment Security. July 2013. http://www.ides.illinois.gov/LMI/ILMR/Fracking.pdf

[29] "Illinois is losing jobs because of fracking delays." Chicago Tribune. August 21, 2014. http://www.chicagotribune.com/news/opinion/editorials/ct-fracking-jobs-illinois-edit-0822-20140821story.html

[30] "Fracking in Southern Illinois Raises Widespread Concerns." Natural Awakenings Magazine. October 2013.

Oil had its heyday in the middle of the last century in southern Illinois, and the opportunity is likely minimal.[31]

Coal

While the percentage of Illinois coal used at Illinois power plants has decreased[32], Illinois is ranked second in the nation[33] for its recoverable coal reserves, and Illinois production has increased[34] over 2010-2012; indeed, worldwide estimates call for continued growth in coal use. A look at the coal industry in Illinois (provided by the ISGS and updated in 2013[35]) shows that while the industry, including locally, is still active, much of the lands in southern Illinois' underground mines appear to have been aggressively mined, especially in the case where the coal is closer to the surface. This may imply that the coal industry in the near future will not only be facing pressure from environmental regulations currently being put in place by the EPA, but also pressure from increasing costs for extraction.

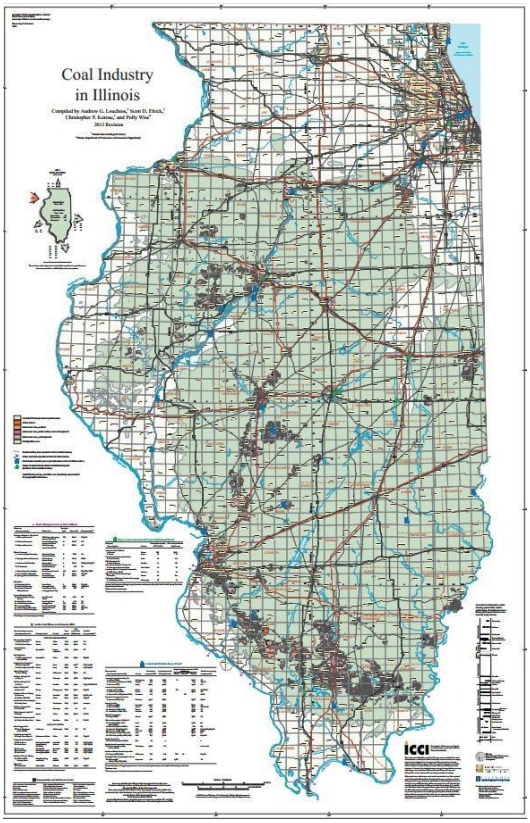
http://www.nachicagonorth.com/CHI/October-2013/Fracking-in-Southern-Illinois-Raises-WidespreadConcerns/

[31] United States Energy Information Association. "Illinois State Energy Profile," last updated March 27, 2014. http://www.eia.gov/state/?sid=IL [32] "The Illinois Coal Industry." Illinois DCEO, 2008. https://www.illinois.gov/dceo/AboutDCEO/ReportsRequiredByStatute/TheIllinoisCoalIndustryJune2008.pdf

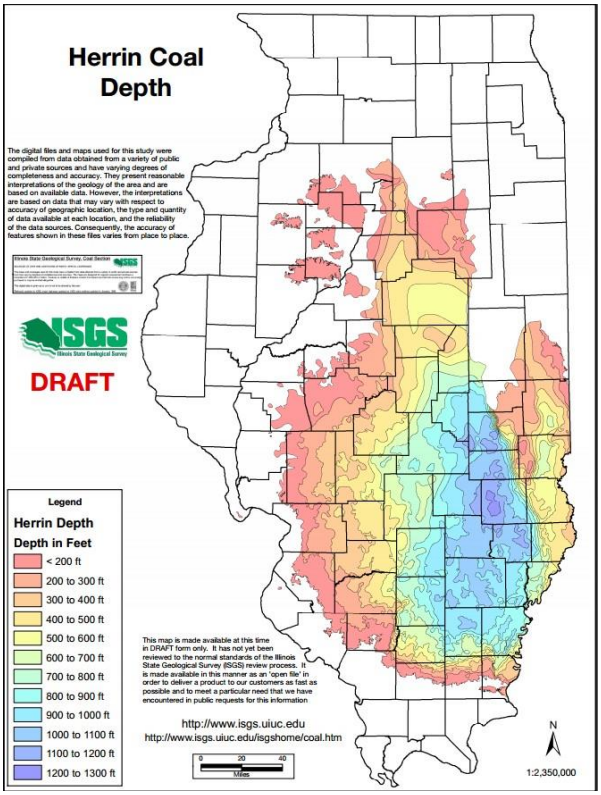
[33] United States Energy Information Association. "Illinois State Energy Profile," last updated March 27, 2014. http://www.eia.gov/state/?sid=IL [34] "Illinois Coal." Office of Mines and Minerals, Illinois Department of Natural Resources. 2011.

http://dnr.state.il.us/mines/public/asr2011.pdf

[35] Illinois State Geological Survey. 2013. http://crystal.isgs.uiuc.edu/maps-data-pub/coal-maps/pdffiles/2013-coal-industry.pdf



Illinois coal industry - green is coal and darker areas are mine locations.
Source: Illinois State Geological Survey



Depth of Herrin Coal seam; areas in red are nearer to the surface.
Source: Illinois State Geological Survey

Clean Energy

Although unemployment remains high, one study showed that over the 2009-2012 period, Illinois ranked third in the nation for new business starts.[36] How much of this benefit is coming to southern Illinois? Regarding "clean energy" business, an extensive report by the Environmental Law and Policy Center[37] prepared in July 2011 listed totals for "clean energy" companies in Illinois, including wind, geothermal and solar:

- Wind energy: 152 companies
- Geothermal energy: 89 companies

36 Hillig, Terry. “Positive growth? Some crowing over new Illinois report.” Illinois Business Journal. http://www.ibjonline.com/positive-growth-some-crowing-over-new-illinois-report

37 “The Clean Energy Supply Chain in Illinois: Wind, Solar and Geothermal.” Environmental Law and Policy Center. July 2011.
“http://elpc.org/wp-content/uploads/2012/02/ELPC-ILCleanEnergySupplyChain-Revised02152012.pdf

- Solar energy: 96 companies

In southern Illinois (even extending to the southernmost 20 counties), the grand total of the companies was two geothermal (heating/air) companies and one solar company. Barring a dramatic change since 2011, much room for improvement exists to benefit the people and industry of southern Illinois.

Looking Forward

The Energy Opportunity

In July 2014, the Illinois DCEO released its five year economic plan[38] for the state, which included a list of “industry clusters” or areas of expertise in the state that are primed for growth. They included:

1. Advanced materials
2. Agribusiness, food processing, and technology
3. Biomedical/biotechnical
4. Clean energy
5. Information technology and telecommunications
6. Machinery and fabricated metal products manufacturing
7. Transportation and logistics

The Illinois Science and Technology Coalition is based in Chicago and is tasked with bringing increased innovative and collaborative activities to the state. They expanded upon the DCEO’s economic plan with their technology roadmap.[39] Along with other technology areas, they identified biofuels as an important area already under consideration at AEI, and stressed the value of the Southern Illinois Research Park[40] and business incubator.

In 2006 TIP Strategies prepared an analysis for Jackson County. Noting the abundance of economic, natural and cultural assets, they made the following recommendation:

> The plan identified two major university-related opportunities for local economic development: 1) local commercialization of research, especially in advanced materials and energy and 2) aviation and automotive related programs located at Southern Illinois Airport.

[38] The Illinois Economic Development Plan." Illinois DCEO. July 2014. http://www.illinois.gov/dceo/Documents/DCEOEconPlan_FULLPDF_vJuly1_2014.pdf
[39] "The Illinois Science and Technology Roadmap." Illinois Science and Technology Coalition. September 2014. http://www.illinoisinnovation.com/filebin/ISTC_RoadmapFINAL.pdf
[40] Southern Illinois Research Park. http://researchpark.siu.edu
To help advance local commercialization of energy research, AEI (then the Coal Research Center) worked with Connect SI starting in 2009 to pursue energy solutions for southern Illinois:

> The "Connecting with the Future of Energy" series, co-sponsored by the SIUC Coal Research Center and Connect SI, joined members of our community in a conversation with energy experts to explore the future of energy resources in southern Illinois.
>
> The discussion series included approximately four events each year focusing on various aspects of energy and how those aspects related to southern Illinois. Past topics have included: Wind Power, Energy Sustainability, Biofuels, Coal Mining, Energy Saving Techniques for Local Government, New National Initiatives and more![41]

The presentations were informative and spurred valuable discussion, but the talks were not specifically focused on a unified plan for southern Illinois.

Later, Connect SI convened "industry cluster" teams of economic development experts and other community representatives to consider the southern Illinois future for sectors such as energy. Industry trends, market and opportunity analyses were prepared, and workshops held. The Vital Economy Alliance[42] was contracted to guide the process. In their market assessment[43] (PPT), they identified cogeneration/combined heat and power production (CHP) and algal biofuels, based in part on the fact that each of these have a wide range of user markets and good potential future growth. Waste-to-energy was another area that received some extra attention in a later report. While the effort stalled when funding ran out, the work they have completed will be useful in assessing future direction.

Numerous state organizations have recognized the potential for energy industry development in southern Illinois, with all scenarios having SIU playing a central role. New innovations are often conceived as research, followed by development and commercialization, so we start at the beginning by considering research.

Energy Research

Researchers at SIU have been at the forefront of energy technology and policy for decades. A few examples of SIU faculty research projects are presented below in the context of current events and initiatives in southern Illinois and our closest neighbors. SIU energy research areas range across disciplines including chemistry, biology, materials science, engineering, forestry, computer science and physics. Many other initiatives at SIU revolve around the topic of energy;

[41] Connect SI. http://www.connectsi.us/energy.htm
[42] Vital Economy, Inc. http://www.vitaleconomy.com/
[43] "Initial Market Assessment – Industry Cluster." Vital Economy, Inc. 2009. http://connectsi.us/WebFiles/Cluster/Energy_Cluster_Initial_Energy_Market_Assessment.ppt
however this document focuses in on SIU energy research, and the role it can play in the region's energy future.

Coal/CO2

Considering the historical importance of coal to the southern Illinois region, as well as the deep expertise at SIU related to coal extraction and utilization, it's likely that coal will remain a foundational part of the energy mix in southern Illinois going forward. It is impossible to consider coal without including the challenges of climate change and environmental impact related to burning of fossil fuels. Among a growing body of research, recent study in Nature[44] concluded that fossil fuels would have to stay in the ground in order to meet the 2℃ climate target. Regarding the potential of carbon capture and storage:

> Carbon capture and storage would have only "a relatively modest effect" on how much fossil fuels can be used because of its expense and late introduction, the scientists added. (BBC.com[45])

On the other side, many groups including Advanced Energy for Life[46] (a Peabody Energy initiative) and the Institute for 21st Century Energy[47] (US Chamber of Commerce) call for continued coal use to "help end energy poverty" and "help keep America secure, prosperous and clean," respectively. These organizations provide suggestions for regulations, policies, and investments in technology in order to be able to continue to use coal.

SIU researchers have been looking for safe, clean and efficient ways to use coal for a long time and are looking at innovative solutions to solve the big problems.

> SIU Research - Dr. Tomasz Wiltowski: The potential liabilities of geologic sequestration have caused a shift in the focus of research from Carbon Capture and Sequestration (CCS) to Carbon Capture and Utilization (CCU) technologies. AEI proposes to build on concepts related to the chemical sequestration, or rather, utilization, of carbon dioxide as an alternative to geologic sequestration. Specific topics to be investigated range from theoretical modeling to lab scale studies of biological, chemical, and electrochemical conversion of carbon dioxide to products such as hydrocarbons, alcohols, etc.

[44] McGlade, Christophe, and Paul Ekins "The geographical distribution of fossil fuels unused when limiting global warming to 2 °C." Nature, 517, 187–190, January 8, 2015.

http://www.nature.com/nature/journal/v517/n7533/full/nature14016.html [45] Harrabin, Roger. "Fossil fuels: The 'untouchable reserves." BBC. January 7, 2015. http://www.bbc.com/news/science-environment-30716664

[46] Advanced Energy For Life. https://www.advancedenergyforlife.com/

[47] Institute for 21st Century Energy, U.S. Chamber of Commerce. http://www.energyxxi.org/energy-worksfor-us

Feature: Chemical Utilization of Coal

Dr. Ken B. Anderson, SIU professor of Geology, has invented a technology that can solubilize coal and biomass using only water and air, while producing only miniscule amounts of carbon dioxide or other pollutants. The technology, called Oxidative Hydrothermal Dissolution, is patented by SIU and licensed to startup company Thermaquatica. They are working with partners to develop the technology that will enable fuels and valuable chemicals from coal and biomass.

SIU Research - Dr. Yanna Liang: Biological coal conversion (BCC) has attracted extensive attention during recent years. Production of methane through BCC has been a commercial reality in several parts of the world. In the United States, the two most prolific coal-bed methane (CBM) producing basins are the Powder River and San Juan, contributing 80% of the total CBM production in the US. In states east of the Mississippi river, where > 95% of coal is bituminous, CBM has not been as successful. As of now, little work has been done on methane production from bituminous coal. Dr. Liang's group has proven that it is feasible to convert bituminous coal to methane through BCC. Currently, equipped with the knowledge of the microbial community, the proteins and pathways involved in BCC to methane, the group is optimizing methane production rate and preparing this technique to be used both in situ and ex situ for obtaining methane from coal.

Feature: Miner Health and Safety

Dr. Y. P. Chugh, SIU professor of Engineering, is a long-time fixture of the southern Illinois coal industry, and an expert on miner health and safety. He and his group operate one of two longwall dust control testing facilities in the nation at the Coal Development Park in Carterville. Dr. Chugh is also the inventor of a system for dust control in mines that was patented by SIU, has been licensed to a startup company and is in use by industry.

SIU Research - Dr. Sam Spearing: In the past seven years, Dr. Spearing's research has had $1.4 million of federally, state and industry funded research mainly associated with mine design and safety. Currently this group is working on three funded projects: one on the behavior of coal pillars under weak foundations (i.e. Illinois Basin conditions) with and without backfill; another on stress corrosion cracking associated with mine rockbolts and a final on a new method to accurately determine the load in installed rockbolts (i.e. axial, shear and bending components).

BioEnergy

In its study "A Bright Future for the Heartland,"[9] the Union of Concerned Scientists state that 47% of the Midwest's renewable energy generation could come from biopower by 2030, through co-firing of coal with biomass. However, SIU's Ira Altman and colleagues[49] reported in 2014 that in Missouri, co-firing would be unlikely to take off without "additional economic or policy incentives or regulations" - as long as externalities related to coal such as pollution and health care costs are not taken into consideration. Increased funding from the federal government for R&D, tax credits and a carbon tax on fossil fuels are mentioned as policy intervention possibilities. Many other studies provide insight into the many variables involved in energy decisions.

> SIU Research - Dr. Ira Altman: Dr. Altman is specialized in the organization and development of emerging rural industries such as renewable energy from agriculture and alternative energy generally. Dr. Altman's coal related research investigates various economic perspectives of coal to power gasification and sequestration was well as coalbiomass co-firing. In the past he has contributed to projects that analyzed the regional economic impacts, financial feasibility and organizational development of cellulosic ethanol, corn ethanol, biopower facilities such as anaerobic digesters, landfill methane and direct combustion and co-combustion as well as cleaner coal facilities such as gasification and CO_2 sequestration systems.

The battle is underway to identify bio-replacements for diesel,[50] jet fuel[51] and gasoline.[52] The battle gets ugly sometimes, with legacy oil and gas producers doing whatever they have to do to maintain[53] their competitive hold on the market on one side, with fiery upstarts changing the rules on the other. Some states and regions are aggressively implementing policy initiatives to boost bio-potential.

[49] Liu, Zuoming, Ira Altman and Thomas G. Johnson. "The feasibility of co-firing biomass for electricity in Missouri." Biomass and Bioenergy. Volume 69, October 2014, Pages 12–20. http://www.sciencedirect.com/science/article/pii/S0961953414003286

[50] Lane, Jim. "xF Technologies: Biofuels Digest's 2015 5-Minute Guide." Biofuels Digest. January 12, 2015. http://www.biofuelsdigest.com/bdigest/2015/01/12/xf-technologies-biofuels-digests-2015-5-minuteguide/

[51] Culverwell, Wendy. "Colorado's Red Rock Biofuels investing $200M in jet-fuel project." Portland Business Journal. January 12, 2015. http://www.bizjournals.com/denver/blog/earth_to_power/2015/01/colorados-red-rock-biofuels-investing200m-in-jet.html

[52] Lane, Jim. "Rising capacities, shift to distributed models and policies are top advanced biofuels trends, says E2 report." Biofuels Digest. January 7, 2015. http://www.biofuelsdigest.com/bdigest/2015/01/07/rising-capacities-shift-to-distributed-models-andpolicies-are-top-advanced-biofuels-trends-says-e2-report/

[9] Martinez, Claudio. "A Bright Future for the Heartland." Union of Concerned Scientists. July 2011. http://www.ucsusa.org/sites/default/files/legacy/assets/documents/clean_energy/A-Bright-Future-for-theHeartland.pdf

[53] "Oil Price Drop Takes Toll on U.S. Biofuels Industry." NACS. January 12, 2015. http://www.nacsonline.com/News/Daily/Pages/ND0112156.aspx#.VLU88CvF-aI

What's happening in Illinois? Production of ethanol in Illinois most recently was falling[54] due to pressure on the margins, but the outlook for ethanol exports[55] is bright. In 2006, the Illinois "AllAmerican Energy Plan" called for 20 new ethanol plants within five years; at the moment Illinois has 13.

> SIU Research - Dr. David Lightfoot: The aim of this line of study is to identify the regulatory networks that increase grain yield and cellulose d lignin depositions in response to nitrogen supply in a biofuel crop plants and to develop new uses for the cellulose and lignin byproducts. The aim is to determine which of the metabolic modifications are responsible for increased yield, increased cellulose fiber deposition and increased value as a feedstock. Plant metabolism will be altered in ways that improve both biofuel characteristics and alternate uses of plants by products.

Renewables/Efficiency

The majority of jobs created in "cleantech" over the past years have been in renewables (solar, wind) and energy efficiency. Many colleges and universities across Illinois have renewable energy and sustainability centers and institutes, or programs of study. Many consider this area as "mature" in terms of its impact on the economy; however much work remains in improving the performance and price of renewables and energy efficiency measures.

> SIU Research - Dr. James Mathias: Recent work involves projects at two local industries and has focused on decreasing energy use through improved insulation, Variable Frequency Drives (VFDs) to operate motors at lower speeds, improved lighting, and utilization of waste heat to be used to dry organic materials. The recommendations of some of these projects have been implemented at these industries and additional work is currently ongoing to make further improvements.

Feature: Enki Technology, a company based on technology developed and patented by SIU faculty, was chosen for the Cleantech Group's "Global Cleantech 100" in 2014. Enki offers "tunable, multi-functional coatings for solar and electronics applications."

> SIU Research - Dr. Kyle Plunkett: Although cyclopenta-fused polycyclic aromatic hydrocarbons (CP-PAHs) have been synthesized for many decades to provide compounds useful to elucidate PAH aromaticity or to create geodesic structures, very few CP-PAHs have been utilized as active components in electronic devices. This

[54] Sapp, Meghan. "Corn futures fall below $4 a bushel as ethanol production slips." Biofuels Digest. January 7, 2015. http://www.biofuelsdigest.com/bdigest/2015/01/07/corn-futures-fall-below-4-a-bushel-asethanol-production-slips/

[55] Sapp, Meghan. "Ethanol exports up 31% on year but that's nothing compared to 2020." Biofuels Digest. December 8, 2014. http://www.biofuelsdigest.com/bdigest/2014/12/08/ethanol-exports-up-31-on-year-butthats-nothing-compared-to-2020/

research group is interested in developing new synthetic methods to access the scalable synthesis of novel CP-PAHs that possess unique photochemical and electrochemical properties. These materials serve as active components in organic electronic devices including organic photovoltaics and organic field effect transistors.

Grid/Storage/Distributed Energy

Recently, some organizations have been talking about "the need for a new utility business model."[10] As more and more residents can power their homes with renewable solar panels during the day, utilities might soon be out of a job. However, not so quick: solutions are lacking for storing the extra power generated during the day for use at night, so what do we do then? A system that's standing by to understand how you use energy and how to balance your needs with what's available on the grid at any given moment is something of a holy grail.

SIU Research - Dr. Ian Suni: This research group has published extensively on electrochemical thin film coating methods, including electrodeposition, electroless deposition, and galvanic deposition. Our coating research targets a wide variety of applications, including both traditional and alternative energy. An example is a recent report of stoichiometric electrodeposition of $CuGaSe_2$, one component of the alloy $Cu_xIn_{1-x}Se_2$ (CIGS), an important photovoltaic material. Another current project involves electrodeposition of metals and metal oxides for use as supercapacitor materials for energy storage on the electric power grid, for example. The group is also studying another coating system, Ti and Zr diffusion coatings, for potential application to enhanced corrosion resistance of the furnace and boiler tubes during oxyfuel coal combustion.

Feature: Article in the Saluki Times, 10/24/13: Kemal Akkaya, associate professor of computer science at Southern Illinois University Carbondale, received a $298,112 National Science Foundation grant to explore ways to protect consumer privacy as the more resilient, but inherently nosy, Smart Grid[57] gradually replaces our outmoded national power grid. Akkaya said an economical and efficient solution to protecting consumer privacy is to use existing communications infrastructure rather than relying on the Smart Grid for both data collection and communication. Akkaya will test his theory by building a model wireless mesh network at SIU. He will use the model to investigate various privacy protection techniques that limit accessible data. He plans to keep his research open to the public as he is conducting it to maximize the immediate benefit to utility companies, researchers and educators involved in Smart Grid research.

[10] Crofton, Karen. "4 Key Business Indicators Electric Utilities Need To Address." Rocky Mountain Institute. January 15, 2015. http://blog.rmi.org/blog_2015_01_15_four_business_model_indicators_utilities_need_to_think_about [57] "Smart Grid." U.S. Department of Energy. http://energy.gov/science-innovation/energy-usage/smartgrid

SIU Research - Dr. Mohammed Sayeh: Smart grid for power distribution is a very powerful technique that can lower energy consumption by many orders of magnitude. The core idea is to distribute power where it is needed the most. In doing so, we need intelligent sensors and dispatchers. The artificial neural network technology (ANNT) has been proven to be very effective in pattern classification and recognition where it is the main engine of the intelligent systems, and this group is interested in pursuing research that utilizes ANNT for any decision making processes.

Innovation Initiatives

We have discussed energy policy and industry in southern Illinois, as well as some research areas at SIU that correspond to the big energy questions of our day. Already we can see that many options are available for the future of the region; however, many challenges exist to mobilize the region on a common goal and set out on the journey. It takes significant effort and planning to bring the benefits of advanced research to communities, businesses and people. It takes an innovative mindset, and initiatives to overcome the challenges of change. Now we can take a look at other community efforts for inspiration.

California Dreamin'

Unsurprisingly, California leads the US in initiatives[58] supporting secure, clean and affordable energy. Rather than resting on their laurels and waiting to see how other states fare, they take action. The result is that California is the leader in solar, advanced energy investment and electric vehicle sales. They have four times the advanced energy workforce, and most of the related firms respond that above three-quarters of their customers are inside California. Undoubtedly southern Illinois could learn some important lessons from this western neighbor.

Carbon-Free Prosperity?

Climate Solutions and Clean Edge prepared a series of studies entitled "Carbon-Free Prosperity 2025[59]" for the Pacific Northwest region in late 2008 dealing with the opportunities related to green-tech. They conducted interviews, used proprietary data, as well as other data source online and at utility companies. The considered the regions assets, barriers, and suggested five opportunity areas. While they have some bigger metropolitan areas than southern Illinois, they put forth some interesting ideas regarding solar and wind manufacturing, green building services, and sustainable bioenergy, based on the large timber industry. Their ten-point action

58 "California Advanced Energy Employment Survey." Advanced Energy Economy Institute. December 2014. http://info.aee.net/hs-fs/hub/211732/file-2173902479-pdf/PDF/aeei-california-advanced-energyemployment-survey-fnl.pdf

[59] "Carbon Free Prosperity 2025." Clean Edge, Inc. 2015. http://cleanedge.com/reports/Carbon-FreeProsperity-2025

plan starts with putting a price on carbon and other regulations and tax credits, includes a focus on facilitating collaboration, and ends with smart-grid building plans.

Adapting to Climate Change

A neighborhood group called "Prospect North[60]" in Minneapolis, MN is looking forward to a warmer, wetter climate as a result of climate change. Their group, which has grown to include the city, county, public housing authority, watershed management and the University of Minnesota, is planning a research district for the particular growing part of town. It will include labs and libraries as well as waste-powered energy, a closed-loop district grid, greenhouse, wind power, and an on-site hydroponic farm. It will also serve as a test-bed for university technology. The aim is to demonstrate a 'future-proof city' that is 'energy independent, zero waste, water and food secure,' and could also 'address a climate of scarcity' in terms of energy and water recycling. While they have a different starting point in terms of being a part of a major metropolitan area, this is an example of more of envisioning a great leap and starting out step by step.

Growing a Rural Innovation-Based Economy

Economic development organizations in rural Kansas used network and asset mapping to identify key industry clusters and linkages among the region's business initiatives. The "Kansas Opportunity Innovation Network (KOIN)" aimed to combine business, technology and economic development and incorporate the natural benefits of a close-knit urban community, for the improvement of rural business outcomes. The result was a new kind of network that spanned many industries and created critical mass for the rural region. The result is a more connected business community with increased business success.

A Path: Common Goals for a Community Initiative

Now that we've looked at the current energy profile of southern Illinois, as well as some research directions at SIU and innovation directions of trailblazer communities, it's time to shine the light on our path forward. As is apparent through the above discussion, energy is a complicated issue and often emotional as well. Further, even at the most basic levels, there are many different groups, ideals and opinions in southern Illinois.

A 2011 Paul Simon Public Policy Institute study[61] provides insight into what moves southern Illinois residents. No one likes paying taxes, and few trust anyone in state or federal government; this is not a big surprise. However, local government is viewed with less suspicion. Also, what may come as a bit of a surprise to some is a strong support of the coal industry and coal miners, as well as farming and farmers; due to the long history of contributions by these

[60] Dovey, Rachel. "Minneapolis Has a Plan for the Most Resilient Neighborhood in the Country ." October 15, 2014. http://nextcity.org/daily/entry/minneapolis-climate-change-resilience-neighborhood-plan
[61]Jackson, J., & Leonard, C. The Climate of Opinion in Southern Illinois Continuity and Change. 2011.
industries and workers to the development of southern Illinois, a strong feeling of support persists.

With 70% of electricity generation for local consumers currently coming from coal, is it realistic to "shut off" coal power in southern Illinois? What is the optimal balance for energy production and consumption in southern Illinois, and what policies do we need to get there? Can we afford to put solar panels on every rooftop, and what do we do when the sun stops shining? These are questions that can be answered in different ways, depending on what research source you want to reach for. To find the best path for the southern Illinois community, we should investigate the possibilities and take steps toward the best ones. Here is a common ground, simple outline of a path forward, including some of the resources AEI and SIU can contribute, that will help find the answer the big question: What is the future of energy for southern Illinois?

1. **Ask Questions**: Create an energy force composed of SIU, community and industry representatives to help define the opportunities and challenges, or the "big questions," regarding the "future of energy" for the region. This can build upon previous efforts and regional assets.
2. **Find Answers**: Through research and development, help find answers to the big questions. With SIU researchers putting their heads together, and guiding insight from #1 above, priority areas and plans for innovative research initiatives can be developed and carried out. SIU and the Coal Development Park in Carterville can serve as technology testbeds in this phase.
3. **Get Results**: Stimulate growth in new technologies and businesses that creates jobs and expands and supports both 1&2 above. SIU and the Southern Illinois Research Park have strong experience in technology transfer, commercialization and business development, and many more in the community have resources and expertise to contribute.

AEI can serve as a central driving force for these efforts and help to make a bold energy future plan for southern Illinois a reality. With an energy boost from AEI, the region can embark on the journey to a prosperous energy future.

Conclusion

The people and organizations of southern Illinois would benefit from a bold plan of action for the region's energy future. With a unique identity compared to the rest of the state, southern Illinois needs to capitalize upon assets that have already been identified as potential engines of development for the region, such as energy. SIU's AEI is at the crux point of resources needed for the effort, and aims to illuminate a path to a vibrant energy future for the region. To see how you can get involved, visit energy.siu.edu.

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