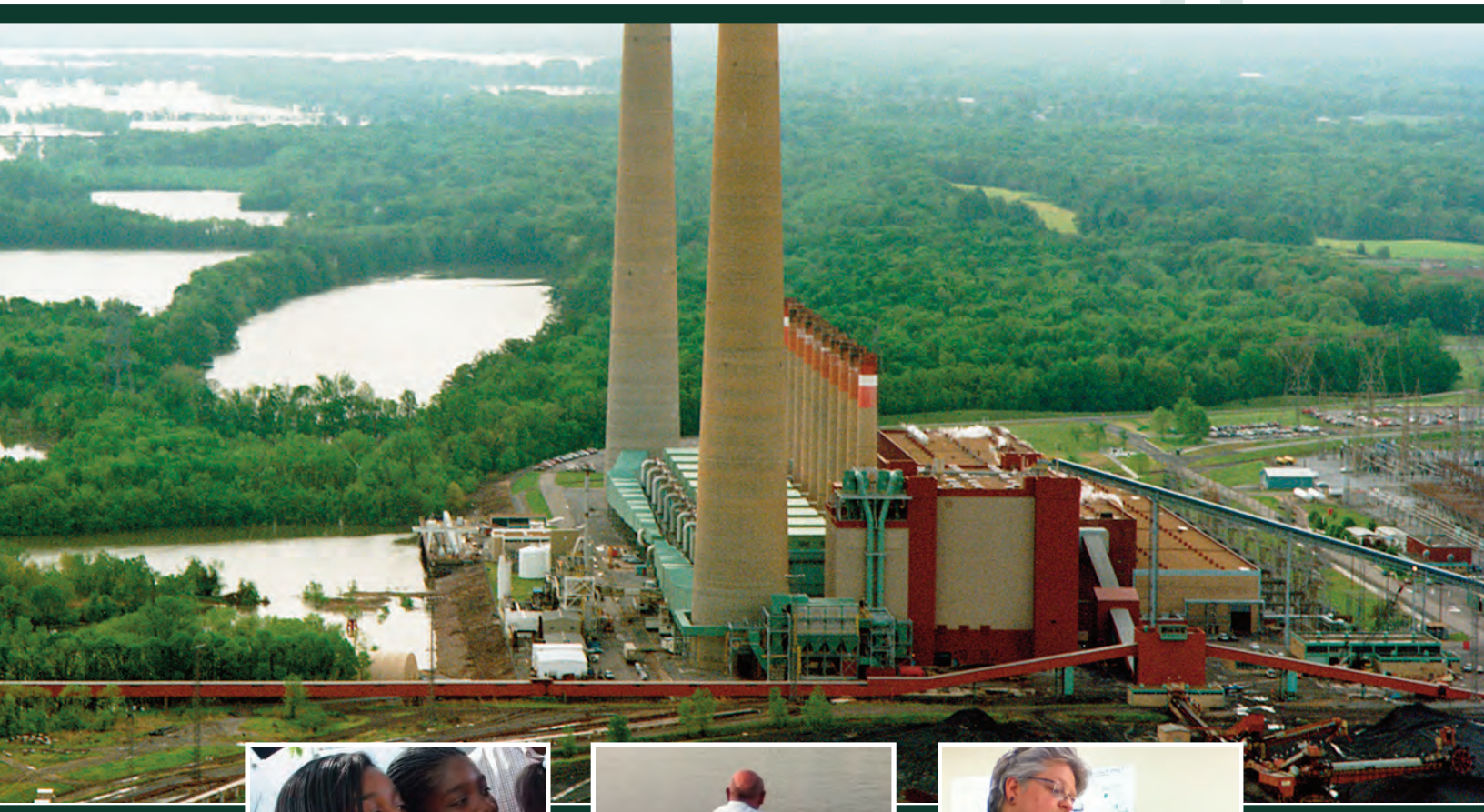
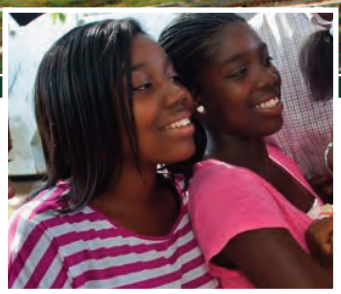
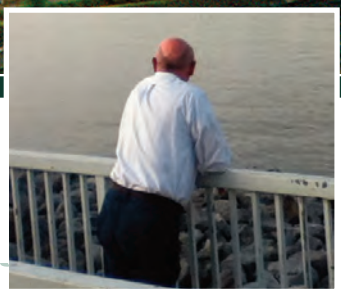
Health Impact Assessment of the Shawnee Fossil Plant







Kentucky Environmental Foundation

Coordinated by Deborah Payne, MPH

Table of Contents

Acronyms

ACI - Activated Carbon Injection

BRFSS – Behavioral Risk Factor Surveillance System

CCR – Coal Combustion Residuals

CDC – Center for Disease Control

CO_2 – Carbon dioxide

COPD - chronic obstructive pulmonary disease

DSI – Dry Sorbent Injection

EIP – Environmental Integrity Project

EPA – Environmental Protection Agency

ELG – Effluent Limitation Guidelines

HIA – Health Impact Assessment

KDEP – Kentucky Department of Environmental Protection

KDOW – Kentucky Division of Water

KEF – Kentucky Environmental Foundation

IRP – Integrated Resource Plan

MATS - Mercury and Air Toxics Standards

MCL – Maximum Contaminant Level

PM2.5 – Particulate Matter 2.5 microns or smaller

PADD – Purchase Area Development District

PDHD – Purchase District Health Department

PILOT – Payment In Lieu of Tax

PPS – Paducah Power Systems

SCR - Selective Catalytic Reduction

SNCR - Selective Non-Catalytic Reduction

SO_2 – Sulfur Dioxide

TRI – Toxics Release Inventory

TVA – Tennessee Valley Authority

USEC – United States Energy Corporation

WKWIB - West Kentucky Workforce Investment Board

Acknowledgements

The Shawnee Fossil Plant HIA was supported by the Health Impact Project, a collaboration of the Robert Wood Johnson Foundation and the Pew Charitable Trusts. The project would not have been possible without the support and engagement of local community stakeholders, the HIA advisory committee, the Purchase District Health Department, TVA, Synapse Economics, and the Georgia Health Policy Center. The views expressed are those of the author(s) and do not necessarily reflect the views of The Pew Charitable Trusts or the Robert Wood Johnson Foundation.

Readers Guide

This summary of the Shawnee Fossil Plant HIA follows the basic six-step process of health impact assessment methodology. Steps include screening, scoping, assessment, recommendations, reporting, and monitoring and evaluation. For ease of reading, after general summaries of the scoping and assessment process, subject matter is divided into four categories where health may be impacted. These include employment, economics, air quality, and water quality. Elements of scoping, assessment and recommendations are addressed in each subject area. The reader is therefore afforded the opportunity to review material according to area of interest.

Executive Summary

The US energy sector is experiencing a rapid transition. For decades, coal was the nation's primary source of energy. In recent years, however, our use of coal has declined. According to the U.S. Energy Information Agency, in 2013, coal comprised only 39% of our nation's energy mix. Record-low natural gas prices, enforcement of air quality policies, and an increase in energy efficiency and renewable energy policies have led many electric utilities to reassess the role of coal in generating electricity, and have moved toward the retirement of coal plants.

Kentucky is also experiencing these energy transitions. In urban and rural communities all over Kentucky, the question of whether to retrofit or retire coal plants stirs heated debates among residents who are concerned with the economic impacts of a retirement, and the health impacts of coal plants that would continue to operate. In the past few years, Kentucky utilities have already decided to retire units at no less than six coal plants, based on changes in customer demand for electricity or the economic benefits of retirement rather than more costly retrofit of the plants. Given our state's high reliance on coal for electricity, tough decisions around the economy, health, and our environment are inevitable.

Health Impact Assessment (HIA) is a tool used to help inform policy or project decisions that frequently fall outside the health arena, and can cover areas such as energy, the economy and the environment. The Shawnee Fossil Plant HIA and its recommendations assess the potential health outcomes associated with retrofits to the Shawnee plant to continue its operations while meeting air quality standards, or retirement of the plant. In this HIA, each element of a decision is considered in relationship to others, ensuring that health remains both a visible element and a priority in decision-making.

The HIA process includes six primary elements: screening, scoping, assessment, recommendations, reporting, and monitoring and evaluation. Through these steps we examined some of the direct health effects associated with potential or expected changes in air and water emissions at the Shawnee plant, as well as indirect effects on health through social determinants such as employment and community economics. One of the most critical aspects of the HIA was the ways in which a diverse range of local stakeholders – including health professionals, industry leaders and organized labor, economic development leaders, the faith community, environmental and conservation groups, and many other community members – shaped the process. In this way the HIA was reflective of its community and stayed relevant to the community.

Key Findings

Findings of the Shawnee Fossil Plant HIA cover a wide range of concerns from economic to environmental health. This HIA is broken into four categories of investigation, addressing health as it relates to employment, the local economy, air quality, and water quality. Just as decision-making is complex, each scenario must be considered in relationship to other scenarios. Taking into account all potential impacts resulting from a particular scenario can help decision-makers alleviate health concerns regardless of the action.

Employment and Health: According to TVA's 2014 draft Integrated Resource Plan, the Shawnee Fossil Plant is listed within the group of power generators that is under evaluation for plant retirement.[i] Closure of the plant could impact social determinants of health including those associated with unemployment. For example, research has observed connections between the cumulative effects of unemployment and risk for heart attack,[ii] reduced physical activity,[iii] poor mental health,[iv] and alcoholism.[v]

The Shawnee Fossil Plant currently employs approximately 300 individuals. An assessment by Synapse Economics estimated that additional retrofits required for the plant might build in as many as 350 additional jobs. The maximum potential job loss from retiring the plant would therefore be approximately 750 jobs (a figure that includes both actual and potential jobs) in 2018 and 2019 ($37.5 million in income) with a minimum job loss of 440 jobs in 2017 ($24.1 million in income).

Local Economy and Health: Closure of an industrial facility can impact community-wide health outcomes by way of reductions in tax base for local services. Closure of the Shawnee Fossil Plant would reduce the $1.1 million in payment-in-lieu-of-tax financial contribution provided to the County. Shawnee's workers are also responsible for $300,000 in payroll taxes paid to the county.[1] This could potentially impact funding for police, fire forces and EMS, critical for public safety. Money is also required to ensure quality education. TVA contributed $3,713,739.97 to the McCracken County School budget for the 2014 fiscal year. Such funds play a role in ensuring the quality of education and sustainability of the school.

For a plant retirement scenario, secondary impacts may result if parents must move away from the area in search of employment resulting in a reduction of income from school enrollment. McCracken (pop. 65,864) and Ballard (pop. 8,253) counties may feel the impacts of increased unemployment the most; unemployment in these counties is at 7.3% and 8.4% respectively.[vi]

Air Quality: Coal fired power plants release harmful air emissions that can impact health. Emissions resulting from coal combustion are comprised of a range of substances

[1] PILOT payments from TVA are based on all of its assets in McCracken County, which includes the Shawnee plant, transmission wires, and other infrastructure. We cannot disentangle how much of these payments are due to Shawnee alone. Therefore, in the absence of the plant, PILOT payments to the county would still exist but would be significantly smaller.

including sulfur dioxide (SO2), Nitrogen oxides (NOx), soot, particulate matter (PM2.5) and heavy metals. Ozone, a by-product of NOx and volatile organic compounds (VOCs), is another harmful compound formed when emissions are exposed to sunlight.[vii] Significant research is available around the impacts of fossil fuel based emissions on health. Along with respiratory concerns such as asthma,[viii,] and decreased lung function,[ix] air pollution has also been linked to heart attacks,[x] atherosclerosis (thickening of the vascular wall)[xi] stroke,[xii] Alzheimer's disease,[xiii] and increased rates of hospitalizations particularly in the elderly.[xiv] While new regulations are anticipated to reduce these rates, not all poor health outcomes will be eliminated.

Poor air quality can impact heart and lung health. According to Kentucky Health Facts, heart disease death rates in Ballard and McCracken counties were 274 and 267 per 100,000, higher than the Kentucky average of 224 and the national average of 113 per 100,000.[xv] Kentucky experiences high levels of both child and adult asthma. The prevalence of asthma in adults in Ballard County is 16% while it is 15% in McCracken County. The prevalence of asthma in the region for children is 15.8%, greater than the Kentucky rate of 10.7% and the national rate of 8.4%.[xvi]

Water Quality: Coal plants generate large amounts of combustion waste, also called coal ash. This ash can contain varying levels of heavy metals influenced by the concentration of metal deposits within the coal itself. Metals commonly found in coal ash include arsenic, manganese, boron, chromium, and selenium. Environmental conditions such as acidity can affect the ability of metals to leach out of ash into surrounding ground and surface waters. Depending on the level of exposure, consumption of untreated ground water or fish contaminated by heavy metals can impact public health.

With the addition of Dry Sorbent Injection (DSI) technology commonly used to prevent sulfur dioxide emissions, the process could contribute up to an additional 3% to the existing ash load, depending on the sulfur content in the coal. However if a DSI system uses sodium-based sorbent, heavy metals such as arsenic can become mobile, increasing the risk of leaching and the threat to public health water systems.[xvii]

According to a review of EPA documents, coal ash has contaminated groundwater in three aquifers under and around the Shawnee Fossil Plant.[xviii] The level of risk to public health may be considered low, however, due to utilization of public water systems installed to address previous groundwater contamination.

Recommendations

The HIA recommendations cover three main decision-making opportunities with the Shawnee Fossil Plant: retrofit technology; the TVA Integrated Resource Plan pertaining to future energy production scenarios, and; community economic transitions planning associated with economic development and industry. Decisions in each area are assessed for both environmental and social determinants of health. The purpose of the HIA recommendations is to provide decision makers at TVA with health based information as it determines future activities at the Shawnee plant and to provide local governments,

economic development and health agencies with data to best inform decisions for the protection of public health.

Recommendations to promote best health outcomes within retrofit and retirement scenarios covered four areas: 1.) employment 2.) community economic development, 3.) air, and 4.) water quality. Key social determinants of health focused on transition planning for any change in employment or operations at the plant that might affect community economics while environmental recommendations addressed mitigation and management of environmental pollutants. The recommendations ultimately serve as a measure to inform decisions so that health is a priority within the decision making process.

Economic transitions are perceived to be a significant challenge for the communities surrounding the Shawnee Fossil Plant. Plant retirement will create the greatest reduction in environmental sources of disease while having the greatest impact on social elements of disease. A decision to retrofit the plant for continued operations could lessen the negative environmental health impacts but would also allow both TVA and the community time to make long term planning to mitigate any major economic changes.

Recommendations within the context of a retrofit scenario include:

Economic development agents (PADD, County Judge Executive, Paducah Economic Development)

- City and County Planners should encourage private sector developers to locate new industrial developments in places that minimize emission based health impacts on communities.

- Local community economic development agencies and institutions including Paducah Economic Development, McCracken County Judge Executive and Fiscal Court, Paducah Mayor and City Commission, Purchase Area Development District, and the West Kentucky Workforce Investment Board should remain aware of the impacts that new standards might play in the longevity of plant operations. As the Shawnee Fossil Plant is an older facility it will eventually face retirement. Investments in long term planning now are critical for the smoothest transition possible.

- The County Judge Executive should actively address planning for lost Payment in Lieu of Tax (PILOT) funds in the event of plant retirement.

- Economic Development Agents should consider the range of tax incentives available from the State of Kentucky for the development of industries that produce lower levels of emissions.

Schools

- Schools should track air quality daily through the use of the Air Quality Index and limit children's outdoor activity on bad air days.

TVA:

- TVA should do additional remediation on coal ash to retain metals potentially leached by the DSI process.

Recommendations within the context of a retirement scenario include:

TVA

- TVA should address in the Low Carbon Future Scenario of its Integrated Resource Plan in ways in which energy demand no longer met by the Shawnee Fossil plant can be offset through energy efficiency. Such measures can employ local workers while reducing the impact of emissions on public health.

- TVA should ensure that if the plant is decommissioned, the property is restored to that required of commercial and industrial standards.

- TVA should hire as many of its current employees as possible to work the decommissioning process. If TVA contracts with an outside firm it is recommended that TVA connect as many of its employees as possible with the decommissioning firm for employment.

- TVA should provide retraining opportunities in renewable energy and energy efficiency work for Shawnee employees in order to help offset potential unemployment.

- TVA should provide various agencies dependent on TVA funds including McCracken County Schools and the McCracken County Government sufficient time (at least one year if possible) to plan for economic transition.

- TVA should provide agencies working with local re-employment endeavors including the Paducah Economic Development Corporation, Purchase Area Development District (PADD), and the West Kentucky Workforce Investment Board (WKWIB), sufficient time (at least one year, if possible) to seek funding to help facilitate reemployment and retraining transitions for dislocated workers.

- TVA should provide Paducah Economic Development, PADD, and WKWIB a full workforce census at the earliest point possible.

Recommendations within the context of both retrofit and retirement scenarios include:

TVA:

- TVA should remediate existing ground water contamination.
- TVA should seek ways to prevent leaching of coal ash into ground water through the lining or relocation of coal ash disposal units.
- TVA should fully disclose levels of contamination to ground water to ensure that current and future local residents do not dig wells to provide water for human consumption.
- TVA should do additional water testing further from the plant property in order to determine the distance that contamination may have traveled.
- TVA should also increase the surface water monitoring in Little Bayou Creek, which has already shown elevated boron concentrations, in order to better characterize the threat to that water body.
- TVA should assess drainage pipe integrity and continue diligence with the assessment of the coal ash dam.

Public Health Department and the Kentucky State Nature Preserves:

- Signage for Fish Advisories should be located in common fishing areas near the Shawnee Fossil Plant including Metropolis Lake and along public spaces of the Ohio River.

Introduction

Industry has played a significant role in the development of McCracken County, Kentucky. Operations such as the Tennessee Valley Authority's Shawnee Fossil Plant have provided employment for thousands of workers over the course of its 60 years of operation.
The facility is situated on the Ohio River and has historically provided power to the United States Energy Corporation's (USEC) uranium enrichment plant. With the closure of the USEC plant, power from the Shawnee plant is now transferred to the broader TVA grid.

The Shawnee Plant contributes to the economy through employee wages, and through funds paid to the state in lieu of taxes. Such direct and indirect financial contributions have affected health through the provision food, housing and insurance to employees, and support for basic community functions such as education, police, and road safety. At the

"The purpose of TVA's Integrated Resource Plan (IRP) is to identify the portfolio most likely to help TVA lead the region and the nation toward a cleaner and more secure energy future, relying more on nuclear power and energy efficiency and relying less on coal."

same time, coal-based electricity generation creates emissions that can cause or exacerbate chronic diseases including cancers and those affecting the heart and lungs.

The growing body of research connecting power plant emissions to poor health outcomes has been a primary driver for stronger air regulations. Within the last 10 years new federal regulations, including the Mercury and Air Toxics Standards (MATS) have been set to address certain power plant emissions. As a result of the President's 2013 Climate Action Plan, new regulations have been proposed for CO2 emissions. Recent energy trends, including the higher costs of mining and transporting coal, and a shift from coal to natural gas have hastened the decline of coal as a fuel source in the U.S. and in Kentucky. For communities that have heavily relied on coal sector jobs, these trends and changes may be difficult. Paducah and McCracken County are not immune to these challenges. Preparation for transitions may be critical for community health and sustainability.

TVA is addressing the new MATS rule at the Shawnee Fossil Plant through the use of Dry Sorbent Injection (DSI) technology. While not traditionally used to address other emissions, TVA anticipates that the implementation of DSI will bring the facility into compliance for all contaminants within the MATS rule.[xix] These contaminants include heavy metals such as mercury, arsenic, chromium, and nickel, and acid gases such as hydrochloric acid and hydrofluoric acid.

TVA, like other utilities, constantly evaluates the steps necessary to provide reliable, affordable electricity to their customers. As articulated by the TVA's Integrated Resource Plan[xx] (IRP), policy and economics determine the composition of this federally operated energy fleet. While coal has historically made up a significant portion of the TVA's energy portfolio, increased availability of natural gas, expanded capacity in the renewable energy sector, and stronger air pollution regulations have directed the company to look towards a more balanced portfolio. The newer portfolio includes expanded use of nuclear power, natural gas, energy efficiency, and renewable energy with a decline in coal based power.

"The purpose of TVA's Integrated Resource Plan (IRP) is to identify the portfolio most likely to help TVA lead the region and the nation toward a cleaner and more secure energy future, relying more on nuclear power and energy efficiency and relying less on coal." [xxi]

According to the TVA's 2014 draft IRP, the Shawnee Fossil plant is listed within the group of power generators that is under evaluation for plant retirement.[xxii] Within the context of a shifting energy economy and concern for financial sustainability, health can frequently be overlooked. The Shawnee Fossil Plant HIA was implemented to identify

potential health concerns associated with retrofit or retirement scenarios at the facility. Through the HIA process stakeholders have worked to inform recommendations that might ultimately help improve health outcomes, regardless of the fate of the Shawnee Fossil Plant.

HIA Process Summary

Health Impact Assessment, or HIA, is a process to inform decision-makers about the potential health impacts of proposed decisions, including those related to legislation, regulations, programs, plans, and projects in diverse policy sectors. The National Research Council defines HIA as: "a systematic process that uses an array of data sources and analytic methods and considers input from stakeholders to determine the potential effects of a proposed policy, plan, program, or project on the health of a population and the distribution of those effects within the population. HIA provides recommendations on monitoring and managing those effects."[xxiii]

HIA has similarities and can be complimentary to Environmental Impact Assessments (EIA) required by National Environmental Policy Act (NEPA). NEPA requires that Environmental Impact Statements (EIS) include analysis of health effects for certain federal agency actions. This analysis, however, has been historically limited. HIA can be used to enhance EIA analysis, meeting the statutory requirements for health effects analysis when conducted within the context of an inter-disciplinary EIA.

The HIA process follows six steps including screening, scoping, assessment, recommendations, reporting, and monitoring and evaluation. HIA components are intended to inform a set of recommendations for decisions at the Shawnee Fossil Plant.

The **Screening** process determined whether the HIA was likely to provide useful information for decision-makers and improve health outcomes. Screening steps included determining a basic level of community interest, outlining potential health impacts of a decision, determining the time frame of the decision, and ensure decision-making promotes and protects public health.

The **Scoping** process established the breadth of potential health impacts associated with decision making at the Shawnee Fossil Plant. Scoping subjects included the populations affected, geographic boundaries, sources of data, assessment methods and included stakeholder engagement. Within this document, after a general introduction to the HIA scope, components of the scoping process are separated into four subject areas: 1) Employment and Heath, 2) Economics and Health, 3) Air Quality and Health, and 4) Water Quality and Health. Information from the assessment and recommendations are also divided into these four categories.

The **Assessment** portion of the HIA evaluated the health impacts of retrofit or retirement scenarios of the plant through a summary of research including literature review, and

analysis of local economic, health, and environmental data. This research established the current health status of the community and addressed the potential influence operational changes might have on health. The assessment addressed potential health impacts on the community, plant employees, and various at risk populations including the young, the elderly and individuals with compromised health. Decisions in each area were assessed for both environmental and social determinants of health and are included in each of the four health topic sections.

Within the assessment process, Synapse Economics, an energy-focused economic analysis agency, was engaged assess potential economic and employment-based impacts of retrofit or retirement scenarios at the plant. While the initial scope of the assessment intended to focus just on DSI technology (plans shared by TVA), Synapse included other potential retrofit technologies they assumed would be required to meet new EPA Mercury and Air Toxics Standards. These included Activated Carbon Injection (ACI), Selective Catalytic Reduction (SCR), Selective Non-catalytic Reduction (SNCR), Effluent Limitation Guidelines (ELG), Coal Combustion Residuals (CCR) and Cooling installation. This expanded analysis highlights the reality that, as companies work to address new standards, differing opinions exist around the efficacy of certain technologies. TVA assumes that DSI will be sufficient to meet the standards. Synapse suggests that additional technologies will be required. Inclusion of these technologies ultimately expanded the initial scope of the HIA. They are included in this report, however, as changes at the plant may fall somewhere within the extremes of the presented analysis.

While the assessment works to create the best possible estimate of various scenarios on health, the report does have limitations. Assessments were made around existing data on air and water quality without much additional modeling. Air modeling on the health impacts of DSI implementation would have created a more thorough understanding of its capacity to reduce pollution and related health outcomes. In some places insufficient data was available to make completely conclusive assessments. These areas have been identified through out the report. Ultimately, the report worked with the resources and material available and recommendations were made accordingly.

Recommendations covered three main decision-making opportunities with the Shawnee Fossil Plant: 1) retrofit technology, 2) the TVA Integrated Resource Plan pertaining to future energy production scenarios, and 3) community economic transitions planning. HIA recommendations provide decision makers at TVA with health based information as it determines future activities at the Shawnee plant and provide local governments, economic development and health agencies with data to best inform decisions around retrofit or retirement scenarios for the protection of public health.

Within in the **Reporting and Dissemination** process, information gathered by the HIA is shared with key decision makers including representatives of the TVA, city planners, economic development leaders, the County Judge Executive and Paducah City Commissioners.

The Monitoring and Evaluation plan lays out a framework for assessment of each stage of the HIA. There are three types of evaluation in HIA: 1) process evaluation gauges the HIA's quality according to established standards and the original plan for the HIA; 2) impact evaluation assesses the HIA's impact on decision-making and its success according to the objectives established during scoping; and 3) outcome evaluation assesses changes in health status and health determinants as the decision is implemented. Monitoring tracks indicators that can be used to inform process, impact and outcome evaluations. The monitoring and evaluation plan strengthens both the integrity of the project and the effectiveness of the HIA.

Screening

The screening process for the HIA identified a number of key factors relating how decision-making at the Shawnee Fossil Plant could potentially affect the health of the community. Two primary scenarios were identified: 1) a retrofit scenario in which the plant implemented modifications to meet new federal standards and remained operational, and 2) a retirement scenario in which the plant was taken off line and the facility decommissioned. The screening process outlined the context, potential health impacts, and time frame of these potential decisions, and determined if the HIA could provide new and important information or insight to inform decision-making.

Manufacturing and energy-based industry had been a primary source of employment in the Paducah area for over 60 years. In 1954, the United States Energy Corporation (USEC) opened the doors to its uranium enrichment plant, a facility that had historically employed over 1000 workers. That same year, the TVA Shawnee Fossil plant went on line to provide power for the energy intensive uranium enrichment process. Both industries have made significant economic contributions to the city of Paducah, KY.

How scenarios were identified:

Within the past few years, several events occurred that could impact operations at the Shawnee Fossil Plant. Shawnee had for decades supplied electricity to the city of Paducah, via the Paducah Power System (PPS). But in 2009, PPS chose instead to invest in a new power plant at the Prairie State Energy Campus in Illinois, in part because the PPS was concerned about the vulnerability of the aging TVA power plant fleet to more protective pollution standards[xxiv]. The most significant external factor impacting Shawnee was the May 2013 announcement of the closure of the USEC plant. This coincided with the end of the company's power purchase agreement for electricity from TVA. TVA no longer has local customers in the immediate area. Such factors could reduce the necessity of the plant within the region.

Other factors potentially affecting plant operations include a number of new and proposed federal policies. The Shawnee plant requires emissions retrofits to meet new EPA Mercury and Air Toxics Standards (MATS). Proposed policies include Effluent Limit Guidelines for coal ash as well as Carbon Pollution Standards to address green house gasses. EPA air and water regulations are the primary form of health considerations for TVA's power plant operations. These regulations, however, do not prevent all potential health outcomes associated with pollution. According to EPA's Toxics Release Inventory (TRI), over two million pounds of toxic emissions are released from the plant annually that can contribute to respiratory, cardiac and developmental issues.

EPA's Risk-Screening Environmental Indicators (RSEI)

As indicated by the EPA, Risk-Screening Environmental Indicators (RSEI) is a model that analyzes factors of industrial operations like the Shawnee Fossil Plant that contribute

to human health risk.[xxv] Scores calculated by RSEI are for purposes of screening and draw attention to releases that potentially pose greater risk over a lifetime of exposure. Factors involved in the modeling include the amount of chemical released, the degree of toxicity, and the size of the exposed population. It should be noted that because of data limitations, RSEI is not a substitute for a site-specific risk assessment. RSEI does not address whether or not a plant is in compliance. It merely relates risk in a manner that compares one source of release to another and identifies areas for further investigation.

As displayed in Table 1, in 2010, the RSEI score for the Shawnee Fossil Plant was twice as high as other electric utilities, over 100 times higher than the county median, over 30 times higher than the state median, and over 150 times higher than the U.S. median. Such statistics suggest that the Shawnee plant may present health risks within the community. This information could be important for informing decisions on retrofit or retirement scenarios as leaders look at ways to reduce associated health risks.

Table 1: RSEI Scores for the Shawnee Fossil Plant Compared to Industry, County, State and U.S. Medians

Year	Facility Score	Industry Median (Electric Utilities)	County Median	State Median	U.S. Median
2006	2,422	872	4	43	10
2007	1,524	815	21	41	10
2008	1,329	784	16	45	9
2009	2,229	485	13	47	7
2010	1,373	534	13	44	9

The screening process identified communities affected by decisions including those living in proximity to the power plant and those employed by the power plant. Air pollution from the plant travels and can particularly impact vulnerable populations such as the young, the old and those with respiratory and cardiac health concerns. Those employed by the plant would experience the greatest financially based health impacts in a retirement scenario.

The screening process also identified key decision makers. These included leadership within the TVA as well as local city planners and economic development agents. Because the TVA is a federally funded operation, regional politicians and their constituents could also potentially influence decisions. For Kentucky, these individuals included Senators McConnell and Paul, and Representative Whitfield.

Existing tools to conduct the HIA included staff time, data from the Toxics Release Inventory (TRI), Environmental Protection Agency (EPA), Center for Disease Control (CDC), and County Health Rankings, information around potential retrofit options and their health impacts, and a community health survey designed by the Purchase District Health Department.

It was then determined that the HIA had the potential for increased conversation around environmental health concerns between health professionals and community leaders as well as increased partnerships between economic and business leaders to address needs for safe, healthy jobs within the community.

Scoping, Assessment, and Recommendations

As previously mentioned, after general summaries of the Scoping and Assessment processes, this HIA document addresses potential health outcomes through four main categories of health. Social determinants include 1) Employment and 2) Economics while environmental categories include 3) Air and 4) Water. For clarity and consistency, each of these categories includes components of scoping, assessment and recommendations.

Scoping: general summary

The HIA Scoping process established the range of factors to consider within the retrofit or retirement scenarios of the Shawnee Fossil Plant. Scoping subjects included the populations affected, geographic boundaries, sources of data, assessment methods, and a narrowing down of health issues on which to focus.

The HIA informs three interrelated decision-making processes:

1. **DSI installation:** Decision making for plant operations at the Shawnee Fossil plant is ongoing. Current actions include the testing of DSI technology to address upcoming Mercury and Air Toxics Standards (MATS) regulations, which are set to go into effect in 2015. It was thought that the permitting process would allow for stakeholder input during the spring of 2014. It was later determined by the Kentucky Division for Air Quality that DSI was considered a minor modification to the plant air permit and therefore did not require a public comment period. Comments will now be submitted in December of 2014 during the open comment period for the general air permit.

2. **Integrated Resource Plan (IRP) development:** In the fall of 2013 TVA began stakeholder engagement for their next Integrated Resource Plan, a document that defines the composition of the TVA's power fleet. This document creates a 20 to 30 year vision to meet TVA's power needs for their customers. The HIA will be used to inform the development of the IRP during the open comment period in December of 2014.

3. **Community Economic and Environmental Planning:** The HIA will be provided to key individuals and organizational leaders responsible for creating plans, or shaping decisions for economic development and health improvements in the Paducah, McCracken and Ballard County areas. These people and groups include the McCracken County Judge Executive, Purchase Area Development District, and the Purchase District Health Department.

Stakeholder Engagement. A "stakeholder" is defined as an individual or group that is potentially affected by decision making at the Shawnee Fossil Plant. Stakeholders for this HIA included local residents, health professionals, industry leaders, labor unions, small businesses, elected officials, conservation organizations, economic development agents, and faith groups. The scope of the HIA was defined by stakeholder input coordinated by the Kentucky Environmental Foundation. Stakeholders engaged in the HIA through:

- A two-day HIA stakeholder training workshop;
- One-on-one and small group meetings throughout the HIA process;
- A community health survey and listening circles conducted by the Purchase District Health Department;
- Social media including an HIA Facebook page.

During the May 2013 HIA stakeholder training workshop, participants from the Paducah and McCracken County community developed a consensus definition of "healthy community" that was used to guide the HIA process:

> A healthy community is a safe, clean, equitable, environment that encourages and supports physical, mental & social well-being; provides healthy choices; and values health as integral and necessary to our quality of life.

Also at the May 2013 HIA stakeholder training, goals of the HIA were determined:

- Inform the debate and discussions around the retrofit or retirement of the Shawnee Fossil Plant;
- Create thorough recommendations to Shawnee decision makers, that address the health impacts associated with all possible decisions and outcomes;
- Build stakeholder engagement including among: community residents & leaders; TVA decision-makers; local businesses and industries, and the health department;
- Elevate health impact considerations in decision-making (e.g. economic development, air and water quality issues) in local and state agencies; and
- Create a blueprint for other communities in energy/economic transitions.

Potentially Affected Populations.

1. Employees, sub-contractors and businesses that service the plant as well as their families that rely on income and benefits.
2. Community members living in close proximity to the plant.
3. Populations in McCracken and Ballard Counties that are part of the economic system connected to the Shawnee plant including contractors as well as service industries that rely on patronage of employees.

Within these population categories, there are specific subpopulations that are more vulnerable to potential health impacts. These include children, the elderly, and racial/ethnic minority communities. For example, children inhale or ingest more harmful chemicals per pound of body weight, than do adults, and may experience exposures, which even at small levels can impact their bodies at critical stages of development.

People of color and low-income people are commonly at greater risk of "fence line" exposures because they tend, nationally, to live closer to polluting facilities. Workers may be at a higher health risk due to workplace hazards, or vulnerable to the risk of job displacement.

Geographic Boundaries. Due to the broad economic and environmental implications of future actions at the plant, geographic boundaries defined for the assessment included McCracken and Ballard Counties. These counties provide the most employees for the Shawnee plant while benefiting economically from its operations. These counties may also experience more of the environmental effects associated with industrial operations, such as water or soil contamination, or impacts from chemicals that tend to fall closer to the source of emissions.

Assessment: Background information and baseline data

This section of the HIA evaluates the health impacts of retrofit or retirement scenarios of the plant through a synthesis of research methods including data collection, literature review, and economic analysis prepared by Synapse Economics. The analysis describes how changes in operations might influence community health. The assessment addresses potential health impacts on the community, plant employees, and various at risk populations.

Community Demographics:

Public health research shows that certain populations, such as the young, the elderly, people of color, and people of different income brackets may be at higher risk to certain poor health outcomes. This includes asthma in children and African Americans,[xxvi] cardiac disease in minorities[xxvii] and the elderly,[xxviii] and poor nutrition for those with low income.[xxix] Identifying community demographics can help determine which populations may be more impacted by economic or environmental health concerns.

Table 2 Shows the demographics of McCracken County, Ballard County, and the City of Paducah, KY. According to the US Census the populations of McCracken[xxx] and Ballard Counties[xxxi] are 65,673 and 8,332 respectively. The population of McCracken is approximately 85.7% White, 11.0% African American and 3.3% individuals identifying as other races including Asian, Hispanic, and Native American. An estimated 21.8% are under the age of 18, 17.8% are over the age of 65 and 16.3% live below the poverty level. The population of Ballard County is 94.4% White, 3.2% African American and 2.4% individuals identifying as other races including Asian, Hispanic, and Native American. An estimated 22.3% are under the age of 18, 18.7% are over the age of 65, and 13.2% live below the poverty level.

Approximately 25,048 residents live in the City of Paducah. The population is 71% White, 23.7% African American, and 5.3% individuals identifying as other races

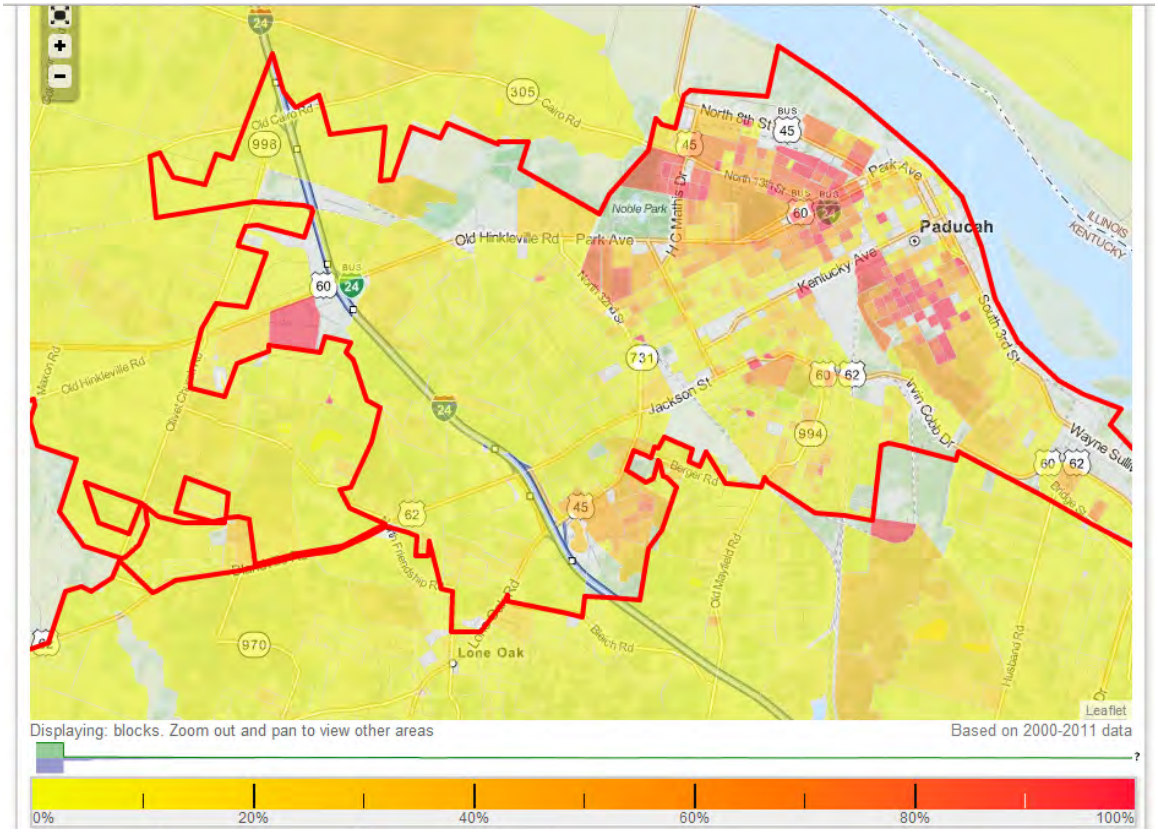
including Asian, Hispanic, and Native American. An estimated 21.8% are under the age of 18, 18.2% are over the age of 65, and 23.2% live below the poverty level.

Table 2: Demographics of McCracken County, Ballard County and the City of Paducah

County/City	Population total (Kentucky 4,395,295)	White (State average 88.5%)	African american (State average 8.2%)	Other race (State average 3.3%)	Persons under the age of 18 (State average 23.1%)	Persons over the age of 65 (State average 14.4%)	Percent living in poverty (State average 18.6%; National average 15.1%)
McCracken	65,673	85.7%	11.0%	3.3%	21.8%	17.8%	16.3%
Ballard	8,332	94.4%	3.2%	2.4%	22.3%	18.7%	13.2%
City of Paducah (within McCracken county)	25,048	71.0%	23.7%	5.3%	21.8%	18.2%	23.2%

Understanding the location of residents with a higher risk to respiratory illnesses can be important for city planning as it relates to industry and emissions. Figure 1 shows where African Americans, a population with higher rates of asthma, typically reside, including the northeast sector of the city along the Ohio River and on the west side of the city by Interstate 24.[xxxii]

Figure 1 Residential concentration of African Americans in Paducah, KY.



Baseline Health Status of McCracken and Ballard counties:

Existing health data in McCracken and Ballard counties serve as a baseline from which the effects of changes in environmental and social health may be assessed. Table 3 provides a summary of rankings for health data for the two counties. It should be noted that different sources of data were utilized for the presentation of local county level data, state and national data. These included the County Health Rankings,[xxxiii] Kentucky Health Facts,[xxxiv] the Kentucky Department of Public Health[xxxv] and the CDC's Healthy People 2020.[xxxvi]

County Health Rankings measure vital health factors, which provide a revealing snapshot of how health is influenced by where we live, learn, work and play.
Kentucky Health Facts, sponsored by the Foundation for a Health Kentucky, aims to provide ready access to key health data for Kentucky communities.
Kentucky Department of Public Health, is home to the state's human services and health care programs.
Healthy People 2020 is a set of science based objectives created by the US Department of Health and Human Services to help work towards improved health across the US. Data is used to move towards improved health nationally.

Table 3: Country Health Rankings of Ballard and McCracken Counties

Health Factor	Ballard	McCracken	Kentucky	Nation
Overall Health: rank out of 120 counties in Kentucky(CHR)	92	37	—	—
Poor Physical Health Days (CHR)	8.6	4.1	4.7	2.6
Low Birth Weight (CHR)	11.7%	8.8%	9.1%	8%
Cardio Vascular Disease deaths per 1,000 (KHF, HP2020*)	274	267	224	113*
Stroke deaths per 100,000 (KHF, HP2020*)	38	43	47	39.1*
Asthma prevalence (percent of adults) (KHF)	15%	14%	13%	13.8%
Cancer, age adjusted per 100,000 (KHF, HP2020*)	188	205	212	172.8*

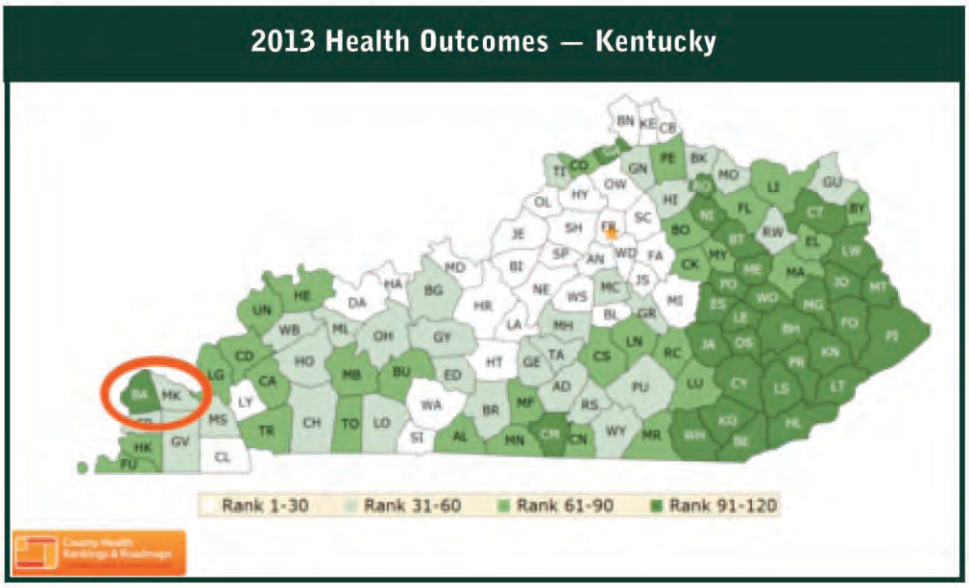
CHR: County Health Rankings
FHK: Foundation for a Healthy Kentucky
HP: Health People 2020

Overall Health Outcomes

According to 2013 County Health Rankings, Ballard County Ranks 92 and McCracken County 37 out of 120 counties in the state of Kentucky for overall health outcomes (Figure 2). This rank, determined by Center for Disease Control's (CDC) Behavioral Risk Factor Surveillance System (BRFSS), includes elements such as premature death, and morbidity that includes poor physical health, poor mental health and low birth weight. For overall health factors, Ballard and McCracken County rank 35 and 20 respectively. Social and economic factors affecting this rank include unemployment, number of children in poverty, level of high school education and level of social support.

Environmental factors include drinking water safety and daily exposure to fine particulate matter. Understanding the overall health of a community can help assess its vulnerability to influences from external health threats. While both counties fall into the first quartile for health factors, Ballard County ranks in the fourth quartile and McCracken in the second for health outcomes. This might suggest that the counties are less healthy than the social and environmental factors might imply.

Figure 2: 2013 Health Outcomes- Kentucky



Poor physical health days

One measure of overall health is poor physical health days. This measure is estimated by survey response to the question, "Thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?" The average for the county provides a general indication of general health status a community may experience. County Health Rankings estimates that Ballard County residents have an average of 8.6 poor physical health days per month while McCracken County has an average of 4.1. While the state average is 4.7 the national benchmark is 2.6. Such data would suggest that both counties are experience poorer health than that directed by the national benchmark.

Low Birth Weight and Infant Mortality

Low birth weight (LBW) provides an indication of both a mother's exposure to various health risks as well as an infant's current and future health status. LBW can affect cognitive development as well as play a role in the infant's risk of premature mortality. While LBW can be influenced by a mother's behavioral factors such as smoking, it can also be influenced by social and economic factors including access to health care and income for sufficient nutrition. Environmental factors such as air quality can also have a significant impact on LBW.[xxxvii] [xxxviii] While smoking can confound outcomes related to air pollution it may also compound health outcomes when air quality is already poor.

The rate of low weight births for McCracken County is an estimated 9% while the rate for Ballard County is at 12%. The rate in Kentucky is 9% while the US average is 8%.[xxxix] McCracken county meets the average for the state, both continue to have higher rates of LBW than other parts of the country. Addressing economic and environmental factors affecting LBW are important for a community's long-term health.

Cardiovascular disease

According to Kentucky Health Facts, heart disease death rates in Ballard and McCracken counties were 274 and 267 per 100,000, higher than the Kentucky average of 224 (KHF 03-07) and the national average of 113 per 100,000.[xl] Many factors can affect cardiovascular disease. Along with behavioral factors such as diet and exercise, environmental factors including contaminated air are an established concern.[xli]

Asthma

Kentucky experiences high levels of both child and adult asthma. The prevalence of asthma in adults in Ballard County is 16% while it is 15% in McCracken County. The prevalence of asthma for children in the region of the Purchase Area Development District is 15.8%, greater than the Kentucky rate of 10.7% and the national rate of 8.4%.[xlii] Hospitalizations of children suffering asthma attacks in the region are at 6.9 per 100,000 compared to 4.9 for the state of Kentucky. Hospitalization of adults for asthma attacks in the region is 8.2 per 100,000 compared to the Kentucky rate of 9.7. This average has fluctuated above and below the state average for the past five years. Poor air quality is a primary cause of asthma attacks.[xliii]

Cancer

Cancer mortality rates in Ballard and McCracken Counties are 188 and 205 per 100,000 respectively.[xliv] The average rate of cancer in the state is higher than the two counties at 212 per 100,000. The national average, however, is much lower at 172.8 per 100,000. A variety of factors have been identified to potentially affect an individual's risk of getting cancer. While genetics play a role, it is estimated that environmental factors such as substances in the air water and soil, and exposures at work, as well as behavioral factors such as diet, smoking and alcohol consumption, contribute as much as 67% to the risk of developing cancer.[xlv]

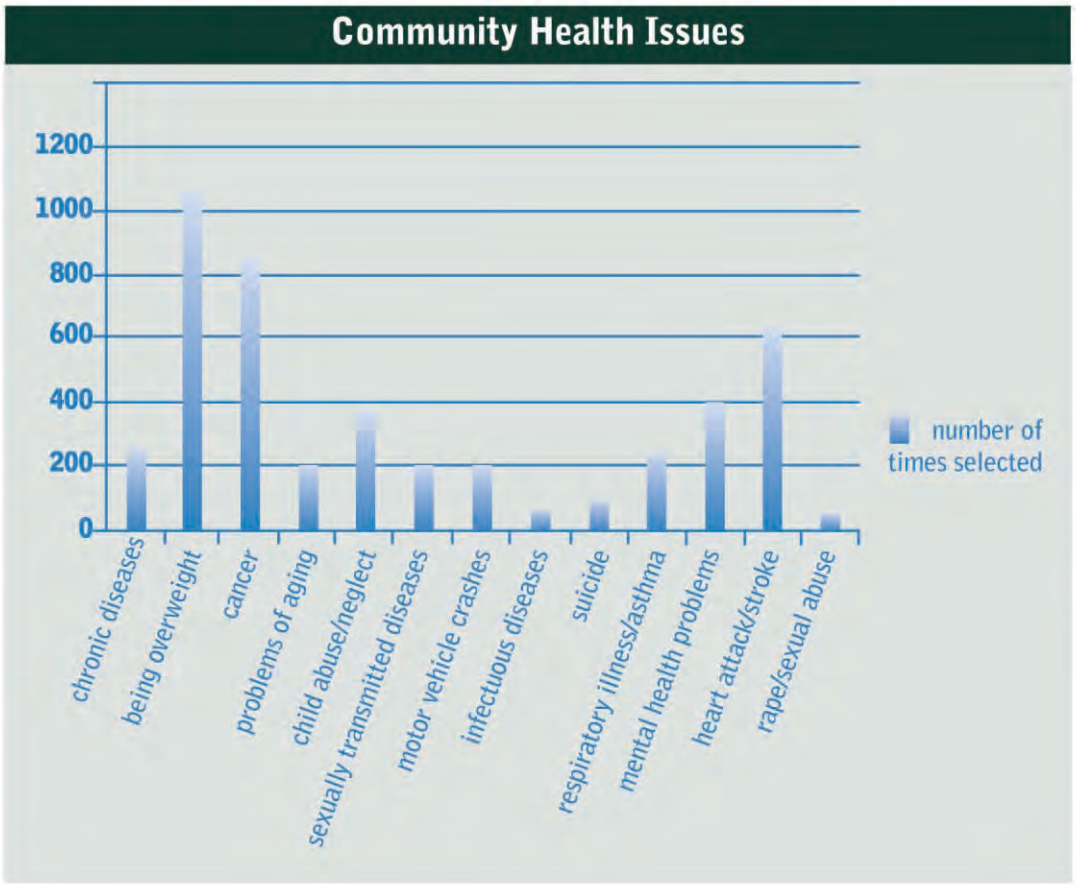
Community Perception of Health: Survey results from the Purchase District Health Department.

As part of its certification process, the Purchase District Health Department implemented a community health survey addressing perceived health concerns within the district. The survey had a total of 1,760 respondents from across the district's five counties: McCracken, Ballard, Carlisle, Fulton, and Hickman. Subjects covered perspectives on a range of topics including community safety, whether or not the community provided a

good quality of life, was a positive place to live, raise children and grow older, and if there was sufficient economic opportunity.

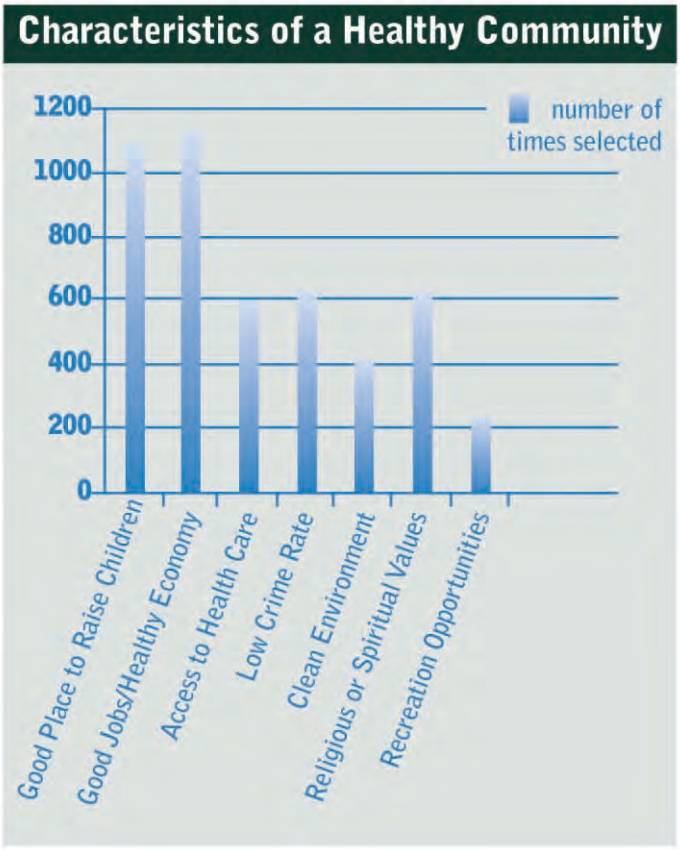
For one section respondents were asked to circle the three most important health issues facing their community. Of 4923 responses, the top three most commonly selected issues were being overweight, cancer, and heart attack/stroke. Results are displayed in Figure 3.

Figure 3: Purchase District Health Survey Responses for Community Health Issues



For characteristics of a healthy community, respondents were asked to circle the three most important characteristics to them. Of 4923 responses, the top three most commonly selected issues good jobs/healthy economy, a good place to raise children, and a low crime rate. A clean environment ranked sixth out of seven response opportunities. Results are displayed in Figure 4.

Figure 4: Purchase District Health Survey Responses for Characteristics of a Healthy Community



Environmental factors such as air and water quality can play a role in heart attacks, stroke,[xlvi] and certain cancers.[xlvii] While survey responses indicated concern around these diseases, community members ranked a clean environment very low on its list of values. Results may indicate limited awareness about the connections between environmental conditions and chronic illnesses that impact the heart and lungs. Good jobs and a healthy economy were cited as the most important characteristic. This set of responses reflects feedback from HIA listening circles that the community is willing to accept a certain amount of environmental risk in order to maintain jobs in industry, even if that industry affects air and water quality.

Table 4 indicates that actual leading causes of death are comparable to those of respondents in the survey.

Table 4: Leading causes of death in McCracken County, KY in 2011

County/City	Number of Deaths in McCracken County (% of All Deaths)	McCracken County* [49]	Kentucky* [50]	United States* [51]
Heart Disease	215 (27.0%)	237.6	205.6	173.7
Malignant Neoplasms (Cancer)	145 (18.2%)	162.6	195.9	168.6
Chronic Lower Respiratory	52 (6.5%)	58.7	63.1	42.7
Unintentional Injuries	37 (4.7%)	50.7	55.7	38.0
Stroke	51 (6.4%)	55.3	43.1	37.9

*Rate per 1000 population

Accounting for baseline health status is critical to understanding the impact that changes in operations at the Shawnee Fossil Plant may have on health. Health data for McCracken County indicates poorer health rankings for respiratory and cardiovascular diseases as compared to state and national rankings. McCracken County also experiences poverty higher than both the state and national averages. Health data for Ballard County indicates poorer health rankings for overall health, low birth weight, cardiovascular disease, and asthma. Environmental factors such as air quality can impact all such outcomes.

Populations at risk to respiratory diseases including African Americans reside predominantly within the northwestern section of Paducah, an area that may be impacted by emissions from local industrial operations like the Shawnee Fossil Plant. At the same time, children under the age of 18 and adults over the age of 65 make up an average of around 40% of the population in both Ballard and McCracken counties. These populations can also experience higher rates of respiratory and cardiac disease affected by local air quality, an element to consider during city planning and decision-making.

Health is composed of many factors. Local perceptions of health prioritize concern for obesity, cancer, cardiac health, and respiratory disease. Employment and having a safe place to raise a family are also important to this community. Ultimately, assessing all data and public prioritization can help inform decision making around future operations at the Shawnee Fossil Plant.

1. Employment and health

Scoping

Investments and operations at the Shawnee Fossil plant affect the level of employment and economic activity in McCracken County and surrounding areas. Retirement of the plant would result in lost jobs from plant operations and other potential jobs associated with building and operating environmental controls. It would, however, generate jobs associated with the decommissioning of the plant for several years after its retirement (assuming this activity occurs after retirement). The retrofit of the plant would keep jobs that are currently at the plant and generate jobs associated with building and operating environmental controls in the future.

Rationale for Inclusion

Stakeholders who participated in listening circles, small group discussions and individual conversations believed that employment and economic impacts are the most critical elements of the HIA. Research has observed connections between the cumulative effects of unemployment and risk for heart attack,[xlviii] reduced physical activity,[xlix] poor mental health,[l] and alcoholism.[li] Areas with high levels of unemployment may ultimately experience expanded populations of homelessness.[lii] Those that are employed but concerned about job security may experience negative attitudes toward their employment as well as develop a negative behavioral relationship with the organization.[liii]

Children are at particular risk to poverty resulting from a parent's insufficient family income. Children face greater morbidity and mortality due to lack of access to health care, nutrition, and poor educational achievement.[liv],[lv]

The Shawnee Fossil Plant provides income and benefits to approximately 300 employees. The plant provides an additional 250 contractor jobs during periods of maintenance and upgrades. According to employee stakeholders, income at the plant is well above the local median household average of $44,000.[lvi] The Shawnee plant contributes to additional jobs in the community through *direct* and *induced* impacts. *Direct* impacts include spending at businesses that supply services directly to the plant. *Induced* impacts include spending of employee wages at local businesses, restaurants, gas stations, and grocery stores.

Employment and health insurance

Employment and the associated enrollment with health insurance means access to health care to treat preventable diseases and reduce overall health care costs for more catastrophic events. The percent of those uninsured under the age of 65 in Ballard County is 17% while the percent uninsured in McCracken County is 16%. The average rate of uninsured is 18% in Kentucky and 11% nationally. Employer-based coverage is the largest source of health coverage in the US, and many unskilled, low paying, and part-time jobs do not offer benefits.[lvii] Health insurance status can change throughout the year for individuals depending on their employment, among other factors.

Individuals without insurance are less likely to receive preventive and diagnostic health care services, are more often diagnosed at a later disease stage, and, on average, receive less treatment for their condition than insured individuals.[lviii] The Institute of Medicine reports that the uninsured population has a 25% higher mortality rate than the insured population.[lix]

Employees at the Shawnee Fossil plant have access to health insurance through TVA. A plant retirement scenario would potentially eliminate that access leading to associated health concerns. Retrofit scenarios could potentially increase the number of jobs and potentially the number of people with access to health insurance.

Unemployment, alcohol and substance abuse

Increased use of alcohol can be a concern for those facing unemployment and an inability to pay for housing. Research by Murphy and colleagues observed an association between use of alcohol during times of recession and housing instability. In multivariate negative binomial regressions, both trouble paying the rent/mortgage (vs. stable housing) and lost (vs. stable) housing were associated with experiencing more negative drinking consequences and alcohol dependence symptoms. The study, however, found that associations were moderated when individuals perceived they had family support. The more support individuals felt, the less negative outcomes were observed for drinking.[lx]

Unemployment and physical activity

Individuals experiencing unemployment also may experience shifts in time use that lead to changes in physical activity. A study by Colman and colleagues observed that while activities such as recreational exercise, TV-watching, sleeping, childcare, and housework increase during times of recession or unemployment, the changes do not compensate for the decrease in work-related physical activity due to job-loss. Ultimately total physical exertion declines, potentially affecting weight, blood pressure and sleep. Populations that experience boom-and-bust economies such as industry or mining may be particularly vulnerable to these fluctuations in physical activity and may experience longer-term effects on obesity and related health outcomes.[lxi]

Employment and psychological well-being

A study by Flint and colleagues worked to establish the direction of causality in the relationship between labor market status and psychological well-being. Transitions between secure employment, insecure employment, unemployment, permanent sickness and other economic inactivity were used to predict changes in psychological well-being over a 16-year period. The study, which utilized data from the British Household Panel Survey (1991-2007) and data from the British12-item General Health Questionnaire (GHQ-12), found that experiencing a transition from employment to joblessness was significantly predictive of poorer psychological well-being. The opposite action of moving into work from unemployment did not, however, have an equal opposite effect.[lxii]

Mandal and colleagues identified that involuntary job loss is particularly challenging for

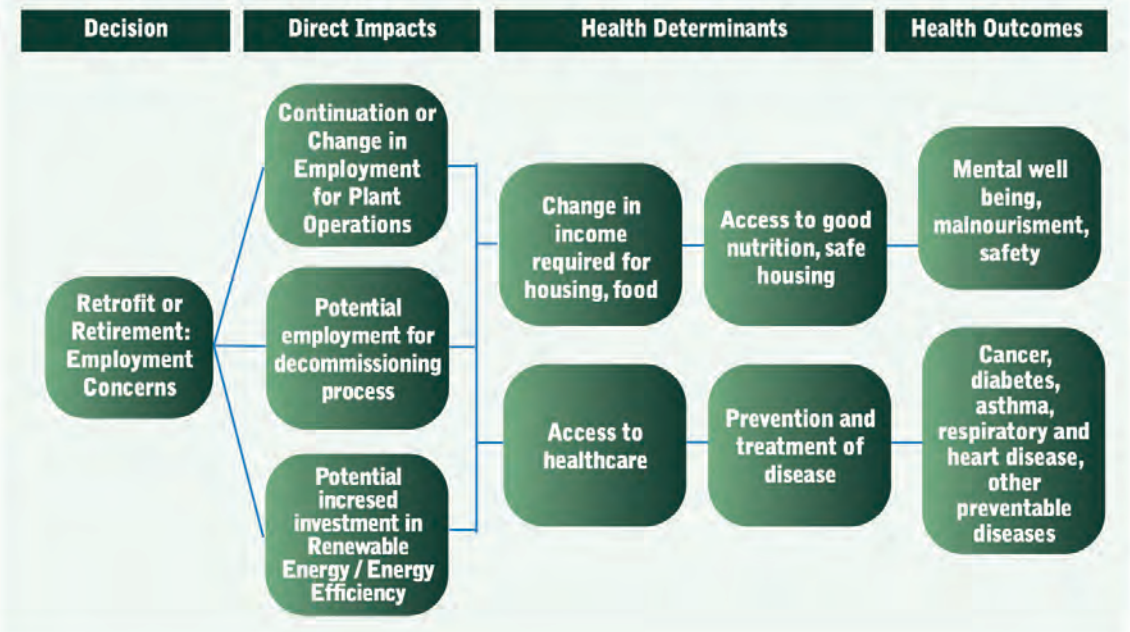
older populations. Out-of-pocket expenditures on all forms of healthcare for seniors with self-diagnosed depression exceeds that spent for treatment of other common ailments such as hypertension and arthritis. Mandal found that reemployment of seniors experiencing involuntary job loss could recapture past mental health status. The research suggested that re-employment of workers would be cost effective for reduction of private and public mental health expenditures.[lxiii]

Employment instability and acute myocardial infarction (heart attacks)

Employment instability is a source of strain that can affect cardiac health. Dupre and colleagues investigated the associations between different dimensions of unemployment and the risks for AMI in US adults in a prospective cohort study of adults (N = 13,451) aged 51 to 75 years in the Health and Retirement Study with biennial follow-up interviews from 1992 to 2010. Risks for AMI were particularly elevated within the first year of unemployment but not thereafter. Even after adjustments for multiple clinical, socioeconomic, and behavioral risk factors, unemployment status, multiple job losses, and short periods without work were all determined to be significant risk factors for acute cardiovascular events.[lxiv]

Pathway. The pathway in Figure 5 shows the relationship between retrofitting the plant to maintain plant operations or plant retirement and associated impacts on employment and health.

Figure 5: Employment based health outcomes



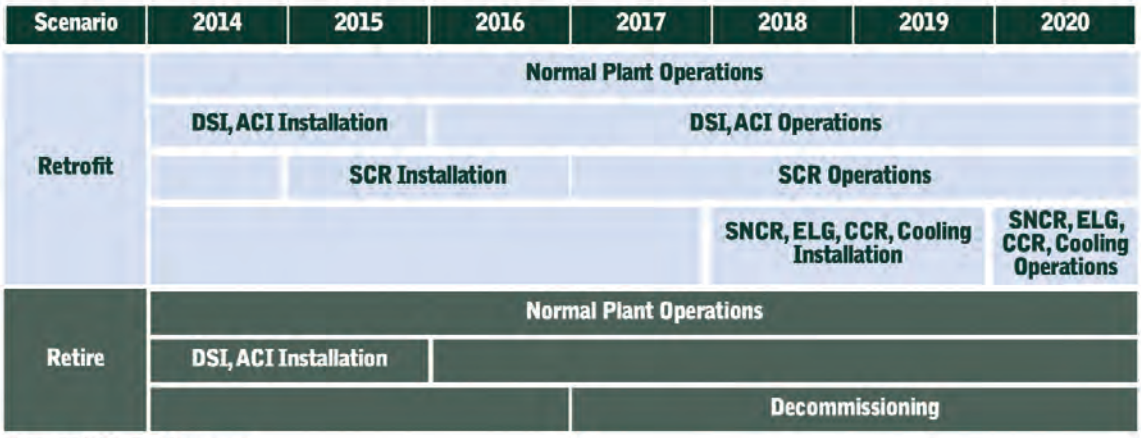
Assessment

Modeling of Employment Activity for Retire or Retrofit Scenarios

Synapse Energy Economics, Inc. (Synapse), an independent energy and economic consulting firm in Cambridge, MA, analyzed the economic and emissions impacts of retrofitting or retiring the Shawnee Plant. This particular model addressed expanded potential retrofits and associated employment at the plant.

Figure 6 shows the assumed timeline of employment and economic activity for retrofit and retirement scenarios. Along with DSI, Synapse included retrofit scenarios for five additional technologies including ACI, SCR, SNCR, ELG, CCR and Cooling installation. Two scenarios affect the economic impacts of plant retirement. These include 1) a net loss of employment from future plant operations (including foregone installation and operation of new retrofits), and 2) a net gain of employment from decommissioning the plant after its retirement. (Further detail on economic impact modeling is provided in the Methodology section of the report in the appendix.)

Figure 6: Timeline of Economic Activity for Retire and Retrofit Scenarios



Source: TVA and Synapse

In the Synapse study total economic impacts are comprised of *direct job or income impacts* at the plant (currently there are about 300 full-time workers) and spin-off effects referred to as *indirect* and *induced impacts*. Indirect impacts occur in industries that supply operations and construction activity. Induced impacts result from economy-wide spending of wages of workers in the direct and indirect industries. The Synapse analysis covered the total economic impacts of retiring Shawnee for three counties in the region (McCracken, Marshall,[2] and Ballard), which is shown in terms of jobs in Table 6 and in

[2] Marshal County was not included in the initial scope of the HIA due to a lack of physical proximity to the plant. Synapse Economics opted to include Marshal County in the economic analysis, however, due to the fact that a number of plant employees reside in this county.

terms of income in Table 5. Since there are no differences in economic activity between the retire and retrofit scenarios in 2014, the net economic impacts are zero for that year. However, there is a discrepancy in economic activity between retiring and operating the plant in later years. According to this assessment, the maximum job loss from retiring the plant would be approximately 750 jobs in 2018 and 2019 ($37.5 million in income) with a minimum job loss of 440 jobs in 2017 ($24.1 million in income).

Table 5: Net Direct, Indirect and Induced Employment Impacts of Retiring Shawnee by County

County	2014	2015	2016	2017	2018	2019	2020
McCracken	0	-410	-480	-410	-690	-690	-430
Marshall	0	-30	-30	-20	-40	-40	-20
Ballard	0	-20	-20	-10	-20	-20	-10
Total	**0**	**-460**	**-530**	**-440**	**-750**	**-750**	**-460**

Source: Synapse and IMPLAN

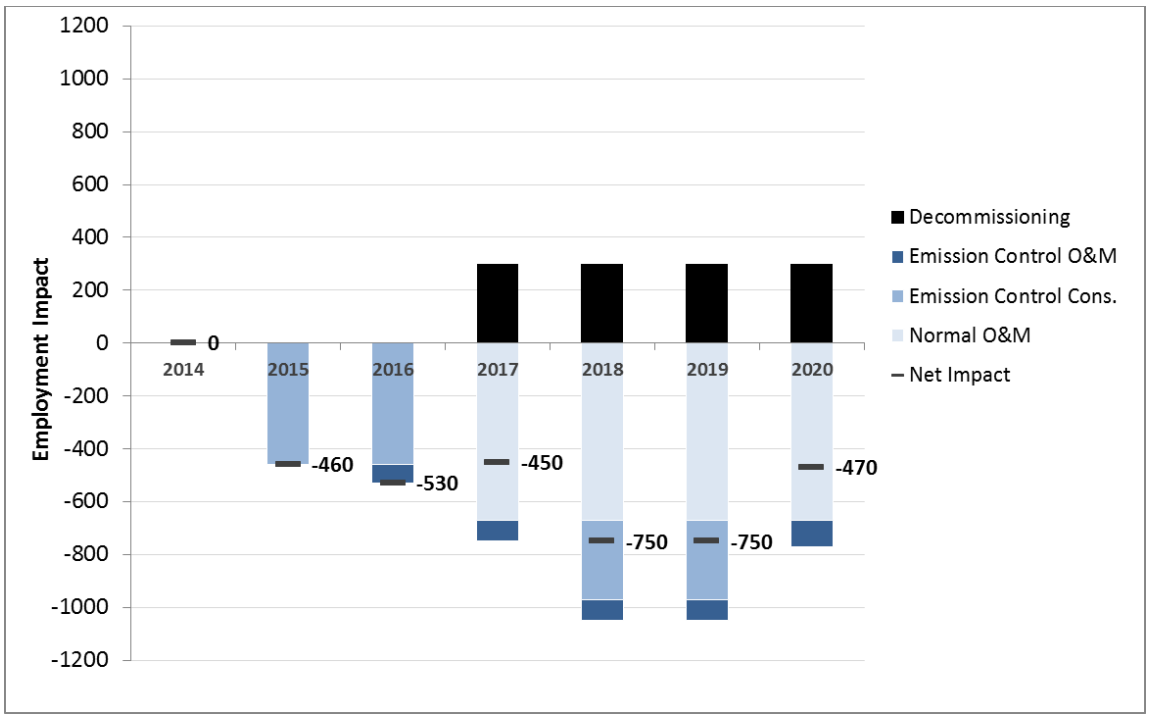
Table 6: Net Direct, Indirect and Induced Income Impacts of Retiring Shawnee by County ($2013 millions)

County	2014	2015	2016	2017	2018	2019	2020
McCracken	$0	-$19.0	-$22.3	-$45.6	-$58.1	-$58.1	-$47.1
Marshall	$0	-$0.9	-$1.1	-$2.6	-$3.2	-$3.2	-$2.7
Ballard	$0	-$0.6	-$0.7	-$1.6	-$2.0	-$2.0	-$1.6
Total	$0	**-$20.4**	**-$24.2**	**-$49.8**	**-$63.3**	**-$63.3**	**-$51.4**

Source: Synapse and IMPLAN

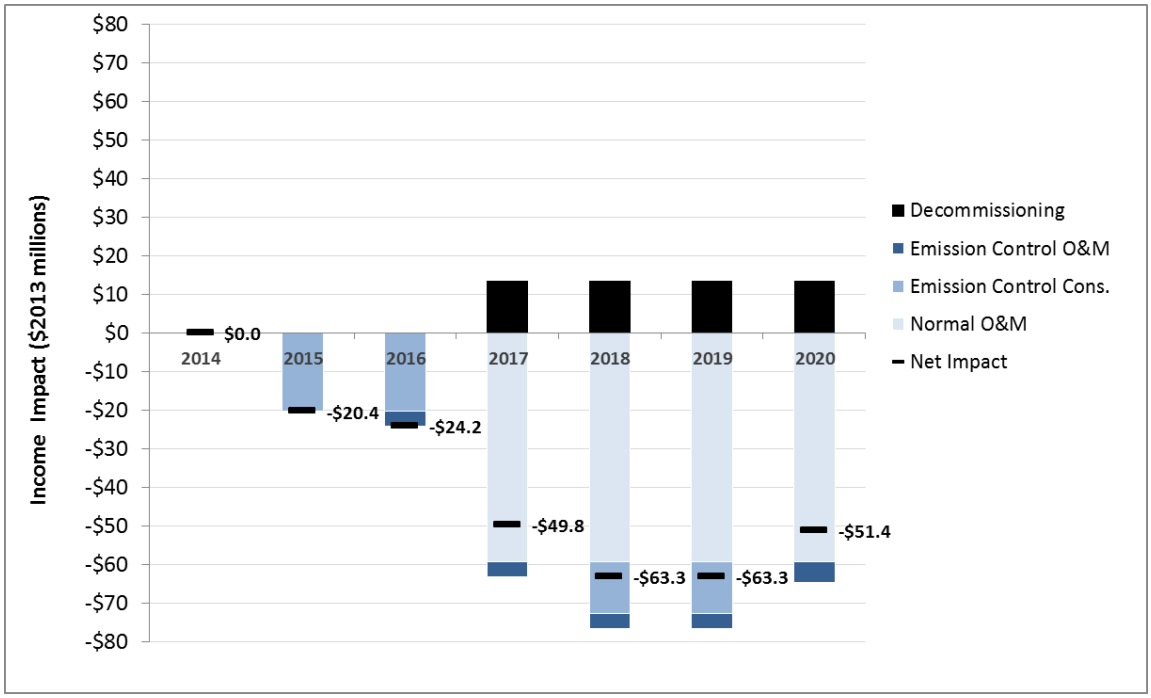
The discrepancy in economic activity levels between scenarios accounts for the net job and income loss with retiring Shawnee in each year. Figures 7 and 8 show the total (direct, indirect and induced) employment and income impacts, respectively, broken down by type of activity. With retirement, decommissioning activity accounts for a gain of 300 jobs per year ($13.5 million in income), which partially offsets the job losses from operating the plant and installing new environmental controls (over 1000 jobs in 2018 and 2019 or $77 million in income). Jobs associated with decommissioning and installing emission controls are short-term, while operations of the plant and controls are long-term. Therefore, after 2020, the job losses would be nearly 800 in each subsequent year—assuming the plant operates at the same capacity as it has in recent history. Significant reductions in employment may result in negative health outcomes for workers at the Shawnee Fossil Plant.

Figure 7: Net Direct, Indirect and Induced Employment Impacts of Retiring Shawnee by Type of Activity



Source: Synapse and IMPLAN

Figure 8: Net Direct, Indirect and Induced Income Impacts of Retiring Shawnee by Type of Activity ($2013 millions)



Source: Synapse and IMPLAN

Table 7: Summary of Health Impacts resulting from reductions in employment at the Shawnee Fossil Plant

Retrofit Scenario	Health Factor	Associated potential health outcomes
Increased Employment for retrofit construction, operation and maintenance	Income for food, shelter, and health insurance	Health outcomes associated with maintenance of nutrition, mental well being, overall good health
Retirement Scenario		Malnutrition, poor mental health, substance abuse, heart disease, obesity, other preventable diseases
Elimination of employment for standard operation and maintenance	Reduction in food security, reduction in financial resources for shelter and health insurance	Malnutrition, poor mental health, substance abuse, heart disease, obesity, other preventable diseases
Creation of employment at plant due to hiring for decommissioning process	Income for food, shelter health insurance	Health outcomes associated with maintenance of nutrition, mental well being, overall good health
Creation of employment with TVA due to hiring of workers for renewable energy/energy efficiency work	Income for food, shelter, and health insurance	Health outcomes associated with maintenance of nutrition, mental well being, overall good health

Assessing the level of risk that a decision might make on the health of the community is an important element of health impact assessment. Decisions can be made using a semi-quantitative method that allows for prioritization of elements of an action plan. Table 8 addresses particular outcomes associated with decisions at the Shawnee Fossil Plant in terms of direction, extent, and severity of that determinant, the likelihood of the determinant happening, who will be impacted by the determinant, and the quality of evidence as it relates to employment and health. For direction, extent and severity, triangles pointing up suggest a positive direction while those pointing down suggest a negative direction. These triangles also incorporate an estimate of how many people might be affected combined with how severe the health impact might be. Four triangles facing up may be an impact that affects a significant number of people in a good way while one facing down would have a negative affect on very few people. Three triangles could either be a large impact on a small number of people or a small impact on a large number of people.

Discussion

There is strong evidence that employment can have a significant impact on health. An increase in employment for retrofit construction, operation and maintenance at the Shawnee Fossil Plant could affect some employees in a positive way. As construction for DSI retrofits has been initiated, this action is considered *likely* to have a positive impact.

A plant retirement scenario could have a significant negative affect on all plant employees, and is considered *possible* due to its listing as a plant under review by TVA. Employment resulting from hiring for a decommissioning process would affect some employees in a positive way. However, TVA has not committed to any plan of plant decommissioning at this point so the determinant is considered *unlikely*. In a retirement scenario, hiring laid off plant employees could have a positive impact on some. However, as the IRP is still in development it is *uncertain* what TVA's priorities will be for their future mix of energy.

Table 8: HIA Impact Analysis Summary of Findings for Health Outcomes Related to Employment

Health Determinants: Retrofit and retirement scenarios	Direction, extent, and severity (how health might be changed, how many are impacted, and ability to mitigate impacts of action)	Likelihood	Distribution (who is impacted)	Quality of evidence
Change in employment for retrofit construction, operation and maintenance	▲▲	Likely	Select employees working on plant retrofits	***
Change in Employment at plant due to retirement	▼▼▼	Possible	All plant employees	***
Change in employment at plant due to hiring for decommissioning process	▲	Unlikely	Employees potentially laid off by plant retirement	***
Creation of employment with TVA due to hiring of workers for renewable energy/ energy efficiency work	▲▲	Uncertain	Employees potentially laid off by plant retirement	***

Direction, extent, and severity:
Impact on many= ▲▲▲▲ or ▼▼▼▼
Strong impact for few or small impact on many= ▲▲▲ or ▼▼▼
Impact on medium number = ▲▲ or ▼▼
Impact on few= ▲ or ▼
Uncertain= ?
No effect= "no effect" or "none*** many strong studies

Strength/quality of evidence:
*** (e.g., many strong studies)
** (e.g., one or two good studies)
* (e.g., no clear studies, but generally consistent with principles of public health)

Recommendations

Employment plays a critical role in overall health. Employment at the Shawnee Fossil Plant provides income that employees and their families use for food, shelter, daily living expenses, and health care. A retirement scenario at the plant would lead to a reduction in the workforce for standard operating procedures. Addressing employment in decision-making within the IRP as well as within the county's long term strategic plan may help reduce the impacts that any employment transition may have on household incomes, and

thus the health of employees and the larger community. Recommendations are therefore made to reduce the health impacts of potential unemployment.

Recommendations made within the context of a retirement scenario include:

- TVA should hire as many of its current employees as possible to work a decommissioning process. If TVA contracts with an outside firm it is recommended that TVA connect as many of its employees as possible with the decommissioning firm for employment.

A study by Navigant Research indicated that the uptick in coal plant retirements creates a market opportunity for cleanup firms, estimating that worldwide revenue from coal plant decommissioning services will total $5.3 billion from 2013 to 2020and the market for coal plant decommissioning in North America and Europe will grow from $455 million in 2013 to $1.3 billion by 2016.[lxv] This boom in decommissioning work is a potential creator of jobs in the local economy where old coal power plants reside, including jobs in engineering, procurement, construction, demolition and remediation.

- It is recommended that TVA provide retraining opportunities in renewable energy and energy efficiency work for Shawnee employees in order to help offset potential unemployment.

TVA is currently increasing investments in energy efficiency and renewable energy operations within its power fleet. Such sources are continuing to expand across the US and have the benefit of generating and saving power without creating emissions. Continued RE and EE investments in McCracken and Ballard Counties would help ease the impacts of reduced employment.

Table 9: Summary of Recommendations Addressing Employment Factors and Health

Recommendation	Justification	Actor	Sample strategy
Hire as many of its current employees as possible to work the decommissioning process.	Employment plays an important role in maintaining health.	TVA	Connect existing Shawnee employees with decommissioning operations.
Provide retraining for TVA employees in renewable and energy efficiency work.	Employment plays an important role in maintaining health.	TVA	Expand existing EE and RE operations in Ballard and McCracken Counties.

2. Community Economics and Health

Scoping

Community economics can affect a range of social determinants of health including access to quality education and public safety. Changes in the operations and employment at the Shawnee Fossil plant could impact local school and county budgets through reductions in income taxes and Payments in Lieu of Taxes (PILOT). For a plant retirement scenario, secondary economic impacts may result if parents must move away from the area in search of employment resulting in a reduction of income from school enrollment. McCracken (pop. 65,864) and Ballard (pop. 8,253) counties may feel the impacts of increased unemployment the most. Unemployment in these counties is at 7.3% and 8.4% respectively.[lxvi]

Rationale for Inclusion

While employment can have immediate health effects on an individual, the presence of an industry can also have broader impacts on the health of a community. Health outcomes associated with education include longer life span,[lxvii] reduced morbidity for common diseases[lxviii] and increased access to income for improved quality of life. Health outcomes associated with road maintenance and police services are strongly connected to safety. EMS and fire services provide direct support during health and safety emergencies. Reductions in funding for these services may impact health. The following research addresses health outcomes related to education, police, road safety, fire services and EMS.

Education and Health:

Research shows that one's level of education can play a significant role in determining health status. A cross sectional, multiple regression analysis by Muller found that a lack of high school education is a powerful predictor of mortality variation among US states. [lxix] Research by Kilander and colleagues observed the education, lifestyle factors and mortality from cardiovascular disease and cancer. Results showed a strong negative correlation between completion of higher education and deaths caused by both cancer and heart disease. [lxx] Levels of education are also often related to the quality and benefits of an individual's job. This can have implications for an individual's access to health care.[lxxi]

A study by Mustard and colleagues evaluated age-specific education and income gradients in morbidity and mortality. Results indicated that while socioeconomic differences played the most significant role in health differences across the lifespan, individuals with lower education levels sought treatment for health concerns more frequently. Those with the lowest levels of income and education faced the highest rates of early mortality. [lxxii]

Research by Meich and colleagues observed how the expansion and decline of educational disparities has affected adult mortality over time.[lxxiii] Meich found that almost all causes of death with increasing mortality rates also had widening educational disparities. Meich suggests that the less education an individual experiences, the higher the risk for chronic disease.

Police and road safety and health:

A range of research suggests sufficient funding is critical for quality police and safety operations. A report by the US Department of Justice identified challenges in staffing police positions as a result of the economic down turn.[lxxiv] Summaries of a survey within the report by the Major Cities Chiefs Association found that 25 percent of respondents experienced service reductions due to budget cuts. As a result, seventeen percent of respondents said that their agency had stopped responding to some calls for service and twenty-six percent stated there had been a reduction in investigations follow-ups, specifically related to property crimes, fugitive tracking, non-felony domestic assaults, financial crimes, computer crimes, narcotics, and traffic cases that may lead to injuries.

A literature review by Elvik summarized current knowledge regarding the effects of speed limit enforcement on public health. According to available research, speeding is the single largest risk factor to vehicle related injuries. Traffic speed also affects impact speed and the severity of injuries experienced in accidents. Sufficient funding of police forces is required to help reduce the public health impacts of speeding.[lxxv]

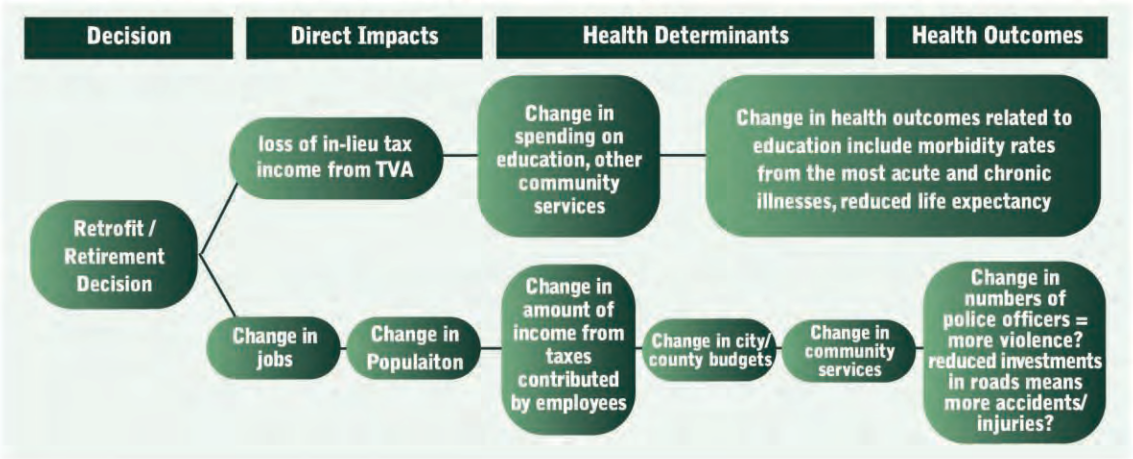
Local Fire Protection, EMS and Health:

Research emphasizes the importance of sufficient financial resources for fire protection and EMS services. The U.S. Fire Administration (USFA) in cooperation with the National Fire Protection Association (NFPA), conducted a needs-assessment survey and identified a concerning lack of appropriate training, as well as inadequate facilities and equipment necessary to maintain basic fire and EMS response capabilities among the U.S. fire service. This was a particular concern in rural and volunteer fire departments.[lxxvi] At the same time, research indicates that EMS services frequently face challenges weighing out how many ambulances to have on hand, how many to contract out, and how many to deploy given a prediction of need.[lxxvii] Budget restrictions may lead to a limitation in services for emergency medical care.

Pathway

Figure 9 shows the pathway relationship between retrofitting the plant to maintain plant operations or plant retirement and associated impacts on community economics and health.

Figure 9: Community Economics and Health Impacts



School funding

PILOT funds from TVA contributed $3,713,739.97 to the McCracken County School system for the 2014 fiscal year, approximately 7% of the nearly $50,000,000 annual budget. These funds have been important to the financial stability of the school. A retirement scenario at the plant could lead to a significant cut in the school system's annual finances. While educational opportunity would not be eliminated for students in the district, cuts in the budget could lead to reductions in programming and increased classroom sizes, factors associated with quality of education.

County funding

Based on historical data on tax collection and discussions with the County Treasurer, Synapse Economics estimated an annual tax contribution of $1.1 million in PILOT payments from TVA to the state that is allocated to McCracken County. Shawnee's workers are also responsible for $300,000 in payroll taxes paid to the county.[3] These contributions make up approximately 4.4% of McCracken County's $32,000,000 annual budget.

Table 10 shows the impacts that a retirement scenario would have on estimated net payroll tax impacts to McCracken County broken down by each activity type--assuming other activities' income would be taxed at a 1% rate.[4]

Given a retirement scenario, payroll tax funds lost to employees doing potential plant retrofits starts at $140,000 in 2015. Full retirement of the plant by 2017 would result in

[3] PILOT payments from TVA are based on all of its assets in McCracken County, which includes the Shawnee plant, transmission wires, and other infrastructure. We cannot disentangle how much of these payments are due to Shawnee alone. Therefore, in the absence of the plant, PILOT payments to the county would still exist but would be significantly smaller.

[4] According to Kentucky Society of Certified Public Accountants, as cited here: http://www.thinkkentucky.com/cmnty/taxincent.aspx?cw=096

$300,000 in lost payroll taxes for normal operating and maintenance of the plant. While an additional $90,000 could be added for contributions of employees working on potential decommissioning operations, $30,000 would be lost to avoided emission control construction. Results of the assessment show a maximum net impact of $330,000 in 2018 and 2019 from lost taxes for normal operation and management, emission control construction, and emission control operation and management. A small offset of $90,000 would be provided by employees working on the decommissioning process.

Table 10: Direct McCracken County Payroll Tax Impacts Resulting from a Shawnee Fossil Plant Retirement Scenario by Activity Type ($2013 millions)

County	2014	2015	2016	2017	2018	2019	2020
Normal O&M	$0	$0	$0	-$0.30	-$0.30	-$0.30	-$0.30
Emission Control Construction	$0	-$0.14	-$0.14	-$0.09	-$0.09	-$0.09	$0
Omission Control O&M	$0	$0	-$0.02	-$0.03	-$0.03	-$0.03	-$0.04
Decommissioning	$0	$0	$0	$0.09	$0.09	$0.09	$0.09
Total	**$0.00**	**-$0.14**	**-$0.16**	**-$0.23**	**-$0.33**	**-$0.33**	**-$0.25**

Source: Synapse, IMPLAN, McCracken County Treasurer and Kentucky Society of Certified Public Accountants

The economies of McCracken and Ballard Counties have faced a number of recent economic transitions. The 2014 closure of the USEC uranium enrichment plant resulted in the layoff of over 1000 employees. Community stakeholders articulated that retirement of additional industries such as the Shawnee Fossil Plant could be financially devastating to the region.

Table 11: Summary of Health Impacts resulting from reductions in PILOT and employment taxes

Retirement scenario	Health factor	Associated health outcomes
Reduction in funding for education	Potential impact on graduation rates	Higher risk for obesity, heart disease, cancer, chronic disease
Reduction in funding for police forces, road safety, fire services and EMS	Reduced response to local crimes / speeding / fires / emergencies.	Reduced safety / increased numbers of accidents resulting from speeding / increased risk of injury from fire / health complications resulting from increased time for emergency response.

Discussion

As found in Table 12 There is strong evidence that education, police and road safety as well as fire and EMS services can all have a significant impact on health. Reductions in funding for these services could affect significant numbers of people, could result in

reduced quality of services and is considered *possible* if the Shawnee Fossil Plant faces a retirement scenario. School age children would experience the impacts of decreased funding for schools while the entire population of McCracken County would be at risk for reductions in funding for police and road safety as well as fire and EMS services.

Table 12: HIA Impact Analysis Summary of Findings for Health Outcomes Related to Community Economics

Health Determinant: retirement scenario	Direction, extent, and severity (how health might be changed, how many are impacted, and ability to mitigate impacts of action)	Likelihood	Distribution (who is impacted)	Quality of evidence
Change in funding for Education	▼▼▼	Possible	School age children in McCracken County	***
Change in funding for police/ road safety	▼▼▼	Possible	All residents of McCracken County	**
Change in funding for EMS/ Fire services	▼▼▼	Possible	All residents of McCracken County	**

Direction, extent, and severity:
Impact on many= ▲▲▲▲ or ▼▼▼▼
Strong impact for few or small impact on many= ▲▲▲ or ▼▼▼
Impact on medium number = ▲▲ or ▼▼
Impact on few= ▲ or ▼
Uncertain= ?
No effect= "no effect" or "none*** many strong studies

Strength/quality of evidence:
*** (e.g., many strong studies)
** (e.g., one or two good studies)
* (e.g., no clear studies, but generally consistent with principles of public health)

Recommendations

Community Economics can have a significant impact on health. Economic assessment of retrofit or retirement scenarios at the Shawnee Fossil Plant provide an estimate of the impact that plant closure might have on the economy of the community. A retrofit scenario could build in as many as 250 additional jobs into the community while retirement may indicate a loss of up to $63 million dollars to the local community in direct and indirect employment. Community economics can play a strong role in social determinants of health. The local economy impacts funding for education, road safety, police forces, fire departments, and EMS. Insufficient funding can affect education and safety, and increase risk of accidents. While economic changes may not have an immediate impact on health, long-term shifts in budgets may create small incremental changes. Planning for economic transitions can help reduce the negative health outcomes associated with a potential plant retirement.

Recommendations within the context of plant retrofits and continued operations.

- The HIA recommends that those that play a role in local community economic development including Paducah Economic Development, McCracken County Judge Executive and Fiscal Court, Paducah Mayor and City Commission, Purchase Area Development District, and the West Kentucky Workforce Investment Board should remain aware of the impacts that new standards might play in the longevity of plant operations and employment.

Retrofitting the Shawnee Fossil Plant with additional pollution controls will lengthen the operational life of the plant, and will maintain employment. Future regulations such as those for CO2 will reduce pollution but at an expense to TVA. This may influence the plant's financial viability. Updates on new regulations can be received by registering through the EPA website: http://www2.epa.gov/laws-regulations/get-involved-epa-regulations#tabs

Recommendations within the context of a plant retirement scenario:

- TVA should provide various agencies dependent on TVA funds including McCracken County Schools and the McCracken County Government sufficient time (at least one year if possible) to plan for economic transition.

- TVA should provide agencies working with local re-employment endeavors including the Paducah Economic Development Corporation, Purchase Area Development District, and the West Kentucky Workforce Investment Board, sufficient time (at least one year, if possible) to seek funding to help facilitate reemployment and retraining transitions for dislocated workers.

WKIB and PADD serve the unemployed, dislocated workers and youth that are out of school and not working. WKIB and PADD work with Rapid Response, an operation that steps in whenever there is a layoff or closure of plant with over 50 employees. This agency offers services that include assistance with unemployment benefits, unemployment insurance, building connections, providing services for mental health counseling, and substance abuse. In addition to those directly affected by plant operations, secondary employees such as gas station workers that are experiencing a decline in business due to the closing of another business can apply for support.

- The HIA recommends that TVA provide Paducah Economic Development, PADD, and WKWIB a full workforce census at the earliest point possible.

The census would include measures such as age, skill set, and number of years to retirement. With this information the PADD will provide information for work force transition, relocation and development of new skills.

- The HIA recommends that the County Judge Executive address planning for lost Payment in Lieu of Tax (PILOT) funds in the event of plant retirement.

Budget development that shifts the dependency of health related programs (fire, safety, police, EMS, etc.) away from PILOT funds may help reduce the impact of any drop in these funds.

- Economic development agents (PADD, County Judge Executive, Paducah Economic Development) should consider the range of tax incentives available from the State of Kentucky for the development of industries that produce lower levels of emissions.

Due to the fact that Paducah has existing levels of air pollution that can impact health the HIA recommends the promotion of economic development that does not exasperate air quality concerns.

Current state tax incentives have the potential of replacing a portion of the funding base lost from existing jobs through promoting new, cleaner industries. Promoting industries with lower emissions should help reduce associated respiratory and cardiovascular diseases while meeting the economic needs of the local community. Proactive preparation for reductions in PILOT funds is urged in order to help relieve the potential financial strain on county budgets. This is particularly important for services that impact health including the police force, the fire department and road works.

Relevant Kentucky Business Incentive Programs include the following (found at: http://thinkkentucky.com/kyedc/kybizince.aspx)

Kentucky Business Investment (KBI) Program
This program provides income tax credits and wage assessments to new and existing agribusinesses, regional and national headquarters, manufacturing companies, and non-retail service or technology related companies that locate or expand operations in Kentucky. Projects locating in certain counties may qualify for enhanced incentives, and Ballard County is listed as an eligible county. This program would fit with Ballard County's existing agribusiness economy, and offers potential for industries that can take advantage of Ballard County's access to three interstate highways and Ohio and Mississippi river transportation corridors.

Kentucky Enterprise Initiative Act (KEIA)
For new or expanded service or technology, manufacturing, or tourism attraction project in Kentucky. KEIA provides a refund of Kentucky sales and use tax paid by approved companies for building and construction materials permanently incorporated as an improvement to real property. It is also available for Kentucky sales and use tax refunds for eligible equipment used for research and development and data processing equipment. Such incentives for technology and

manufacturing expansion can help diversify the existing economic base. Tourism incentives can take advantage of the region's access to the Ohio River, Land Between the Lakes, and forest and wildlife refuge areas in neighboring Illinois.

The Kentucky Enterprise Fund and the Rural Innovation Fund
These programs provide seed-stage capital to Kentucky-based companies that are commercializing a technology-based product or process. The funds exist to stimulate private investment in Kentucky-based technology companies with high growth potential. The Kentucky Science and Technology Corporation administers the funds under contract with the Council on Postsecondary Education. These can be looked at in conjunction with worker re-training incentives.

Kentucky New Energy Ventures Fund
Provides seed stage capital to support the development and commercialization of alternative fuel and renewable energy products, processes, and services in Kentucky. The funds exist to stimulate private investment in Kentucky-based technology companies with high growth potential. KNEV makes grants of $30,000 and investments ranging from $250,000 to $750,000+. Qualified companies must be Kentucky-based and funds are to be used for business development activities. Due to the region's geographical access to farmland and waterways, the HIA would encourage exploring the use of these funds for biofuel or hydro power project potential, as well as advancing sustainable energy technologies such as wind and solar.

Kentucky Environmental Stewardship Act (KESA)
To be eligible, the company must manufacture an environmental stewardship product, which is defined as any new or improved product that has a reduced adverse affect on human health and the environment or provides for improvement to human health or the environment when compared with existing products that serve the same purpose.

Incentives for Energy Independence Act (IEIA)
To be eligible, a company must construct, retrofit, or upgrade a facility to: 1) increase the production and sale of alternative transportation fuels; 2) increase the production and sale of synthetic natural gas, chemicals, chemical feed stocks, or liquid fuels from coal, biomass resources, or waste coal through a gasification process; 3) increase the production and sale of energy-efficient alternative fuels; or 4) generate electricity for sale through alternative methods such as solar power, wind power, biomass resources, landfill methane gas, hydropower, or other renewable resources. The alternative energy incentives may be an attractive option to utilize a workforce that already has an understanding of the energy industry.

Table 13: Summary of Recommendations Addressing Community Economic Factors and Health

Recommendation	Justification	Actor	Sample strategy
Regional and local development agencies should account for the potential impact that new standards may have on plant operations.	The implementation of new standards may impact the long-term viability of coal plant operations and associated employment.	City and County development offices. City Commission	Registration for updates on new standards can be found at: http://www2.epa.gov/laws-regulations/get-involved-epa-regulations#tabs
TVA should provide the McCracken County School system and the McCracken County Government sufficient time to plan for potential budget deficits associated with reductions in plant operations.	Sufficient time for budget planning may reduce impacts that deficits may have on education, road maintenance and safety.	TVA	TVA alerts McCracken County School Superintendents and the McCracken County Judge Executive as soon as transitions in operations are determined.
TVA should provide the PADD sufficient time (at least one year if possible) to acquire funding to help facilitate transitions for employees.	Sufficient time allows the PADD to maximize funds for transitions for employees.	TVA	TVA reaches out to PADD as soon as decisions around plant operations are formed.
TVA should provide the PADD a full workforce census with the announcement of a plant retirement.	A workforce census ensures that all employee's transition needs are met.	TVA	Example to be provided by PADD for TVA.
City planners should plan for funding gaps created by loss of PILOT funds.	PILOT funding supports services like roads and police forces that affect public health and safety.	City Commissioners, Fiscal Court/County Commissioners, Mayor of Paducah & Paducah City Manager	Include long-term considerations when looking at county budgets that depend on PILOT funds.
Consider the range of tax incentives available from the State of Kentucky for the development of industries that produce lower levels of emissions.	Industries with lower emissions may help prevent respiratory concerns.	Economic development agents (PADD, County Judge Executive, Paducah Economic Development)	

3. Air Quality and Health

Scoping

Coal power plants emit a wide range of chemical compounds that can impact health. The Clean Air Act requires the EPA to set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment.[lxxviii] While standards are intended to protect health, not all risk is eliminated. Gaps in policy allow for higher levels of pollution under certain circumstances. Certain standards require air quality to be measured on a three-year average. This time frame may present a low average but does not account for days when air quality is worse. Power plants are also currently exempt from excessive pollution during periods of start up, shut down, and malfunction. Such windows may lead to bad air that can affect hearts and lungs.

Rationale for inclusion. Along with respiratory concerns such as asthma, bronchitis, and chronic obstructive pulmonary disease (COPD)[lxxix], air pollution has been linked to a broad range of concerns including heart attacks,[lxxx] atherosclerosis (blood clots), stroke,[lxxxi] low birth weight, premature birth,[lxxxii] Alzheimer's disease,[lxxxiii] and increased rates of hospitalizations particularly in the elderly.[lxxxiv] While it is difficult to tie certain health concerns to a specific source of pollution, power plants have been identified as the primary source of SO2 and mercury in the environment, the third leading source of NOx and the fourth leading source of PM2.5.[lxxxv] Health implications of CO2 are less direct; climate concerns can include heat exhaustion, intensified forest fires and drought. They are, however, included in the conversation of this HIA as future regulations of CO2 may impact plant operations.

The TVA is addressing new emission standards for acid gasses required by the Mercury and Air Toxics Standards (MATS) rule at the Shawnee Fossil Plant through the use of Dry Sorbent Injection (DSI) technology. This method, originally designed to remove SO2 from plant emissions, involves the injection of an alkaline powder into the flue gas of a coal plant boiler where it binds with the acidic gasses and is filtered out with other ash.[lxxxvi] TVA expects the implementation of DSI at the Shawnee Fossil plant to bring the facility into compliance with all contaminants within the MATS rule.[lxxxvii] These contaminants include heavy metals such as mercury, arsenic, chromium, and nickel, and acid gases such as hydrochloric acid and hydrofluoric acid.

Historically, standards produced by the Clean Air Act have been critical for improving national air quality. Sulfur dioxide and nitrogen oxides are at all time lows. The reality is, certain at risk populations still experience poor health outcomes associated with air pollution produced by coal-fired power plants. This HIA includes conversations around such air pollution because, even though a plant may be retrofitted, it can still produce health-impacting emissions.

Contaminants released in power plant emissions include:

Sulfur Dioxide (SO_2):

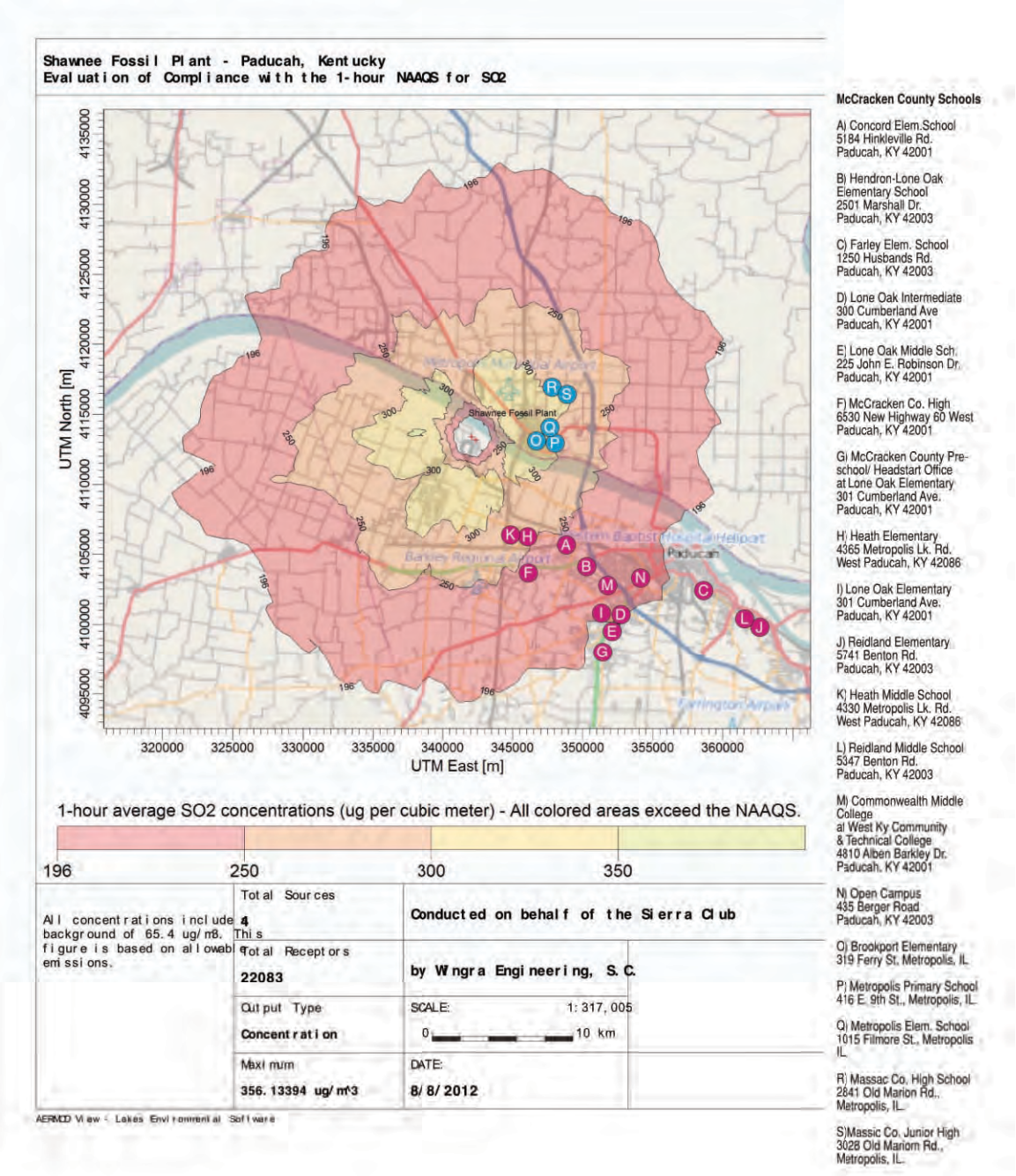
Health concerns related to sulfur dioxide include bronchcoconstriction and asthma. SO2 can worsen respiratory diseases such as emphysema and bronchitis and can aggravate existing heart diseases that lead to hospitalization and premature death.[lxxxviii]

Air modeling is a tool for determining the potential presence or dispersion of a particular contaminant. Different models may present different results. The Sierra Club prepared an air modeling impact analysis of the Shawnee Fossil Plant to help EPA, state and local air agencies identify violations of the 1-hour SO2 national ambient air quality standards, a measure that ensures sensitive populations are not impacted by poor air quality.[lxxxix] Methods used by the Sierra Club included a dispersion modeling analysis that predicted ambient air concentrations for comparison with the one hour SO2 NAAQS. The assessment used 2011 data and the most current versions of EPA standard air modeling software. While TVA has not utilized or made consideration of this model, it is included in this report as a representation of the limited available data.

Through this modeling process it was determined that, based on either currently permitted emissions or measured actual emissions, the Shawnee Fossil Plant may create downwind SO_2 concentrations which exceed the 1-hour NAAQS of 75 parts per billion. Figure 8 shows a map of SO2 emissions from the Shawnee Fossil Plant as well as the geographic area by which a plume might move and the potentially affected communities.

Predicted exceedances of the 1-hour NAAQS for SO_2 extend throughout the region to a maximum distance of 13.2 miles (22 km). According to the analysis, communities in McCracken, Ballard and counties in southern Illinois are impacted by SO2 from the Shawnee Fossil Plant. These areas include over 30 schools and childcare facilities in and around Paducah as well as communities with higher numbers of African Americans, a population that has statistically higher rates of asthma and is particularly vulnerable to poor air quality.[xc] Implementation of DSI is intended to reduce such emissions.

Figure 10: Shawnee Fossil Plant - Paducah, Kentucky Evaluation of Compliance with the 1-hour NAAQS for SO2 with McCracken County, KY and Metropolis, IL Schools



Nitrogen Oxides (NOx):

Nitrogen oxides (NOx) are generated through fossil fuel combustion processes. The primary health concerns result from the formation of ground-level ozone (O3), derived from the exposure of NOx and volatile organic compounds (VOCs) to sunlight. Ground-level ozone exacerbates asthma, scars lung tissue, and can lead to permanent and significant reductions in lung function. Children, people with lung diseases such as asthma, and people who work or exercise outside are susceptible to the adverse effects of ground-level ozone.[xci] Scientific evidence has linked NOx with adverse respiratory effects such as airway inflammation in healthy people and increased respiratory symptoms in people with asthma.[xcii]

In 2013 the Shawnee Fossil Plant released 12,094 tons of nitrogen oxides.[xciii]
While both McCracken and Ballard Counties are in attainment for the one-hour standard for nitrogen dioxide at 100 parts per billion, and the secondary standard annual mean at 53 parts per billion, air quality in the region is not completely healthy.[xciv]The American Lung Association's 2014 "State of the Air" report ranked McCracken County with an F for levels of ozone. No monitoring is available in Ballard County. Grades followed a ranking system for which an A represented no bad air days, and a B represented only 1 to 2 orange days with no red. An F represented 9 days or more over the standard. In 2013 the county experienced 16 days when individuals with asthma and COPD were at high risk to respiratory distress and 2 days when the general population was at risk to respiratory distress. The rankings were measured through the EPA's Air Quality Index, a system that monitors national air quality for ozone and particulate matter.[xcv]Noting poor air days is important for protecting public health.

Particulate Matter (PM2.5):

Particulate matter smaller than 2.5 microns (PM2.5) can have significant impacts on cardiovascular and pulmonary diseases.[xcvi] As no safe level of particulate matter has been identified, PM2.5 has a linear relationship with respiratory and cardiac diseases. Research has shown that as PM2.5 levels increase, emergency room visits for respiratory and cardiac health concerns also increase.[xcvii]

According to County Health Rankings, a system that uses data from the Center for Disease Control (CDC)[xcviii], average daily concentrations of PM2.5 in micrograms per cubic meter in Ballard County are 13.1 and in McCracken County are 13.3. The national benchmark is 8.8, a goal set by the CDC for improved air quality and ultimately improved health. The lower the level of PM2.5 the fewer the risks of negative health outcomes. The EPA's primary standard for PM2.5 is 12 micrograms per cubic meter and the secondary standard is 15 micrograms per cubic meter, measures that take the average of air quality over three years. This is the standard to which TVA must comply.

According to CDC data, both McCracken and Ballard Counties have air quality that is poorer than the EPA's primary standard. However, because the EPA does not utilize the CDC's data, such exceedances do not trigger any kind of regulatory action. TVA operates

in compliance of the three year average. There will be days, however, when air quality is worse than the average and health is impacted. Acknowledging this discrepancy as decisions are made around plant operations may help improve emissions related health impacts.

Mercury:

Coal-fired power plants contribute to one third of man-made sources of mercury in the environment.[xcix] Mercury released into the air rains into waterways, is converted by bacteria into the more toxic methyl mercury and is then consumed by fish. Pregnant women, infants and young children are significantly at risk to high levels of mercury in fish. Methyl mercury exposure in infants, even in small doses, can cause disabilities including blindness, deafness, speech problems and mental retardation.[c],[ci] Mercury can cross the placental barrier and impact fetal development leading to developmental delays later in life.

The Shawnee Fossil Plant emitted 180 pounds of mercury into the air in 2011. Implementation of retrofit technology is expected to reduce mercury emissions to levels that meet new standards. Testing will be required to ensure that DSI is sufficient to meet these new emission goals.

Carbon dioxide (CO2) and other greenhouse gas emissions:

Coal emissions are a significant source of the green house gas carbon dioxide (CO_2). Greenhouse gases contribute to ongoing changes in global climate, which have serious health implications for both local and global populations. Health determinants associated with climate change (heat waves and drought) include dehydration, heat exhaustion and stroke. Droughts can also lead to a decline in crop production, ultimately affecting food availability and nutrition.[cii] Other health impacts associated with shifting weather patterns can include an increase in allergic attacks, and plant or insect-borne diseases.[ciii]

Table 14: EPA criteria pollutants and associated health effects

Pollutant	Associated health effects
Sulfur dioxide (SO2)	Emphysema, bronchcoconstriction, cardiac dysrhythmia, asthma, death
Nitrogen oxides (NOx) and Ozone (O3)	Asthma, scaring of lung tissue, significant reductions in lung function
Particulate matter	Heart attacks, stroke, reduced life expectancy, diabetes, autism, juvenile arthritis, slow fetal growth and low birth weight
Mercury	Blindness, deafness, speech problems, mental retardation

Health outcomes attributed to current plant emissions

Limited data are available on the specific health outcomes associated with air pollution from the Shawnee Fossil Plant. In the report, "Net Loss: Comparing the Cost of Pollution vs. the Value of Electricity from 51 Coal-Fired Plants," researchers from the Environmental Integrity Project modeled power plant emissions with associated premature deaths in 2011.[civ] The peer-reviewed approach, consistent with EPA methods, assessed exposures to emissions of sulfur dioxide, nitrogen oxide, and particulate matter from each of 51 plants. According to the report, the retail value of electricity in 2011 at the Shawnee Fossil plant was $557 million. This amount was compared to the cost of an estimated 70-140 premature deaths related to emissions at the plant. The cost of premature deaths was estimated to be $580 - $1200 million. The net value of lives lost was $23 million. Such estimates present an economic cost/benefit analysis for area planners when determining the financial impacts that an industry may have on community.

Table 15 shows air modeling estimates of 2013 health outcomes related to emissions produced by the Shawnee Fossil Plant. Table 16 presents the leading causes of death in McCracken and Ballard Counties as a point of reference. Just as the CATF study suggests plant emissions contribute to chronic bronchitis, asthma and heart attacks, leading causes of deaths in the area are related to chronic lower respiratory and heart diseases. While no epidemiologic study has been carried out to determine specific impacts of plant emissions on the region's population, poor air quality would not improve the health status of local heart and lung patients.

Table 15: Air modeling estimates of 2013 health outcomes related to emissions produced by the Shawnee Fossil Plant

Health outcomes	Cases per year	Cost in thousands of dollars
Deaths	56	$410,000
Chronic Bronchitis	34	$15,000
Heart Attacks	85	$9,300
Hospital Admissions	40	$930
Asthma Attacks	920	$48
Asthma ER visits	58	$21

*ABT Associates

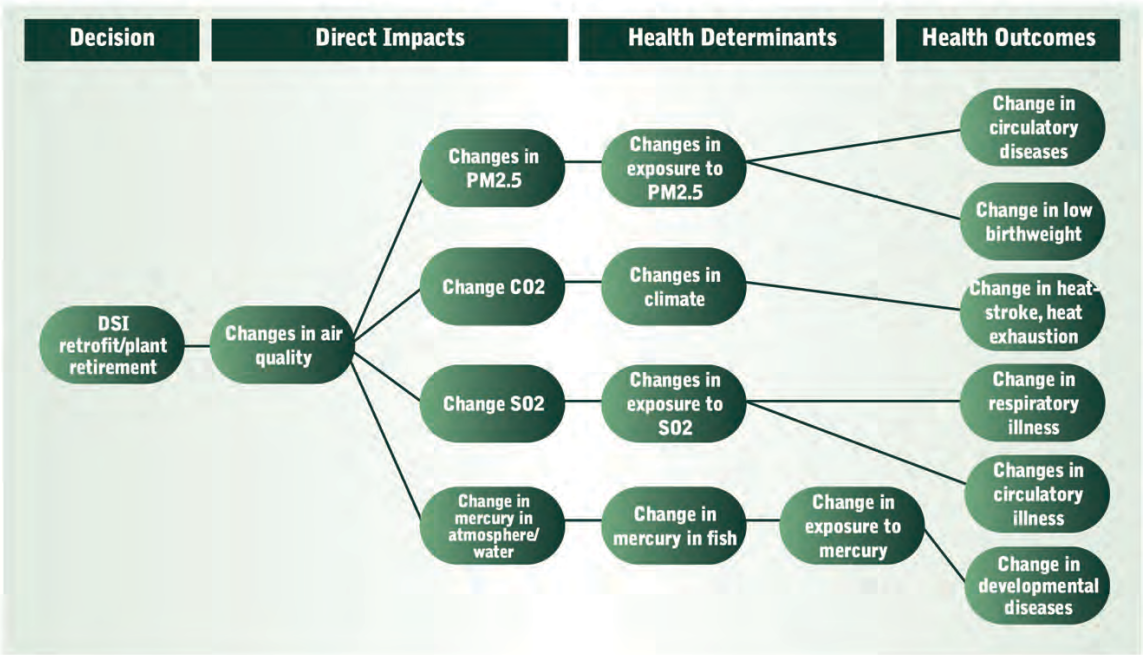
Table 16: Leading causes of death in McCracken and Ballard Counties in 2011

Cause of Death	Number of Deaths in McCracken County (% of all 796 deaths)	Number of Deaths in Ballard County (% of all 98 deaths)	Total number of deaths (% of 894 total deaths)
Heart Disease	215 (27.0%)	28 (28.6%)	243 (27%)
Malignant Neoplasms (Cancer)	145 (18.2%)	19 (19.4%)	164 (18%)
Chronic Lower Respiratory	52 (6.5%)	7 (7.1%)	59 (7%)
Unintentional Injuries	37 (4.7%)	1 (1.0%)	38 (4%)
Stroke	51 (6.4%)	5 (5.1%)	56 (6%)

Pathway

Figure 11 shows the pathway relationship between retrofitting the plant to maintain plant operations or plant retirement and associated impacts on air quality and health.

Figure 11: DSI retrofit/ plant retirement: Air quality based health outcomes



Assessment

Air modeling analysis of DSI and additional retrofit technology

Synapse Economics assessed the time frame in which air pollution would be reduced through retrofits at the Shawnee Plant. The analysis addresses scenarios that represent two extreme possibilities for the plant's future: all remaining units (i.e. 1 through 9) are completely retired or retrofit. It is likely that the future for the plant will lie somewhere in between these two extremes. For instance, as part of a Consent Decree, TVA has stated that it is possible it will retire units 1 and 4 but has not expressed the possibility of retiring other units. This analysis does not look at all possible combinations of unit retirements or retrofits; the resulting impacts should be viewed as "bookend" scenarios.

The retrofit or retirement of the Shawnee Fossil plant will result in a reduction of air pollutant emissions and associated health risks compared to current emission levels. Retirement of the plant would result in the cessation of all emissions at the plant (assuming that no replacement generation is built at or near the site). Table 17 shows the historical and projected emissions levels of sulfur dioxide (SO_2), nitrous oxide (NO_X), and carbon dioxide (CO_2) at the Shawnee plant. As previously mentioned, TVA plans to install Dry Sorbent Injection (DSI) on units 1 through 9 to comply with the U.S. EPA Mercury Air Toxics Standard (MATS). Though TVA has not indicated a plan to do so, Synapse made assumptions in their analysis that DSI would not be completely sufficient to address NOx and mercury emissions. Synapse suggested that Activated Carbon Injection (ACI) would likely be required to sufficiently remove mercury from units 1 through 9. Synapse also assumed that TVA must install Selective Catalytic Reduction (SCR) on units 1 and 4 by 2017 for removal of NO_X.[5] In addition, they assume that TVA will need to install Selective Non-Catalytic Reduction (SNCR) for NO_X removal on remaining units (i.e. 2, 3, 5, 6, 7, and 8) to comply with future, more stringent NAAQS).[6]

The average annual emission levels in recent years (an average of 2010 through 2013[7]) were approximately 27,000 tons of SO_2, 14,000 tons of NO_X, and 8.2 million tons of CO_2. The SO_2 and NO_X levels will decrease with the installation of DSI emission controls. Synapse estimated that by 2020, annual emission levels could reach 8,000 tons of SO_2 (a 70% reduction from current levels) and 6,000 tons of NO_X (a 57% reduction from current levels). However, in the absence of carbon capture technology adoption or compliance with future carbon regulation, they assume that carbon dioxide emissions would persist at levels similar to that of recent history.[8]

---

[5] The Consent Decree specifies that Shawnee units 1 and 4 have the option to be retired, converted to biomass, or retrofitted with Flue Gas Desulfurization (FGD) and Selective Catalytic Reduction (SCR). In the retrofit scenario, Synapse assumes that the units will be retrofitted with SCR and that TVA will claim that DSI is sufficient to satisfy SO_2 removal.

[6] Further detail on the assumptions underlying regulatory compliance and related emissions is provided in the Methodology section of the Synapse report found in the appendix of this assessment.

[7] EPA emissions data for 2013 were only available through September; this year's emissions were extrapolated to the annual level.

[8] It is likely that carbon regulation will be enacted in the U.S. in the near future. For instance, possible compliance options with Clean Air Act Section 111(d) could include an emissions standard or increased energy efficiency and

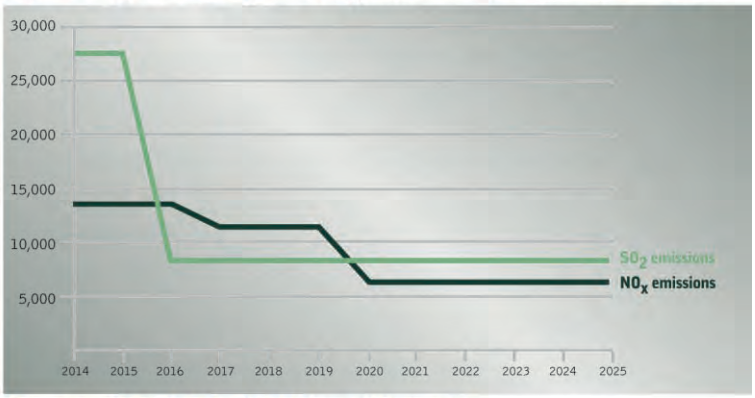
Table 17: Emission Impacts for Select Years (tons)

Air Pollutant	2010-2013 (annual average)	2017 (post-consent decree)	2020 (post-add'l retrofits)
Sulfur Dioxide (SO2)	27,000	8,000	8,000
Nitrous Oxide (NOX)	14,000	11,000	6,000
Carbon Dioxide (CO2)	8,200,000	8,200,000	8,200,000

Source: EPA AMPD database. Synapse SO2 and NOX rate assumptions. SO2 and NOX rounded to nearest thousand, CO2 rounded to nearest hundred thousand.

Figure 12 shows the projected emissions of SO_2 and NO_x by year, assuming that emissions controls are installed. The sharp decrease in SO_2 emissions in 2016 results from the installation of DSI on units 1 through 9. The decreases in NO_X result from the installation of SCR on units 1 and 4 by 2017 and the installation of SNCR on remaining units by 2020.

Figure 12: Annual SO_2 and NO_X Emissions with Installed Controls



Source: U.S. EPA AMPD and Synapse

Anticipated impacts of improved air quality on health

It is anticipated that additions of retrofit technology will improve air quality and reduce associated health outcomes. Retrofits addressing sulfur dioxide and nitrogen oxides, precursors to particulate matter, will reduce respiratory and cardiac concerns such as asthma, COPD and heart disease. According to Synapse Economics, implementation of new air quality retrofits will cut combined SO2 and NOx emissions from 41,000 tons down to 14,000 tons, a 66% reduction. Research has identified a linear relationship between air pollution and health outcomes.[cv] Using this general principal the HIA makes

renewable energy generation which would result in reduced operations at Shawnee. However, Synapse has not accounted for the change in plant operations that would result from such a regulation.

a basic estimation that health outcomes associated with the Shawnee Fossil Plant by Abt Associates might also be cut by two thirds. These estimates are presented in Table 18.

Table 18: Cases of health outcomes associated with emissions at the Shawnee Fossil Plant before and after plant retrofits

Health outcomes	2013 Cases per year	2013 cost in thousands of dollars	2020 cases per year (.66 reduction)	2020 cost in thousands of (2013) dollars
Deaths	56	$410,000	19	$139,400
Chronic Bronchitis	34	$15,000	12	$5,100
Heart Attacks	85	$9,300	29	$3,160
Hospital Admissions	40	$930	14	$316
Asthma Attacks	920	$48	313	$16
Asthma ER visits	58	$21	20	$7

While plant retrofits greatly improve health outcomes, a number of concerns remain. Cases of asthma appear seemingly high as well as the number of heart attacks and deaths. For a general comparison to the 19 deaths associated with plant emissions in 2020, vehicle accidents in McCracken County in 2012 also killed 19 people.[cvi] It is left to the decision makers at TVA to determine whether or not current operations are worth the associated risk. Ultimately, a retirement scenario would completely eliminate pollution based health outcomes. It should also be noted that current levels of emissions may continue to impact health at more elevated levels until either retrofit or retirement scenarios are implemented.

Table 19: Summary of Health Impacts resulting from plant retrofit or retirement scenarios

Scenario	Health factor	Associated health outcomes
Continued operations	Creation of plant emissions	Respiratory and cardiac health concerns
Retrofit of plant with DSI	Reduction in SO2 and other acid gasses. Assumed reduction in mercury and NOx	Reduced risk of respiratory and cardiac diseases. Assumed reduction in risk of mercury related disease (developmental delay, cognitive concerns)
Retrofit of plant with additional modifications (identified by Synapse Economics)	Reduction in SO2, NOx, acid gasses, and mercury	Reduced risk of respiratory and cardiac diseases. Reduction in risk of mercury related diseases (developmental delay, cognitive concerns)
Plant Retirement	Complete elimination of SO2, NOx, acid gasses, mercury	Elimination of health outcomes related to plant emissions

Discussion

As addressed in Table 20 continued plant operations will release emissions that can continue to have a negative impact on the health of residents surrounding the Shawnee Fossil Plant. As it has not been modeled what impact retrofits at the plant, both those applied by TVA as well as those recommended by Synapse Economics, will have on air

quality, it is assumed that these retrofits will affect air quality for all residents around the plant. A full retirement would create the greatest reduction in health impacts related to air pollution. Those that would benefit the most from improved air quality include the young, the elderly, people of color, asthmatics, and those with heart disease.

Table 20: Health Impact Analysis Summary of Findings for outcomes related to Air Quality

Health Determinants: retrofit and retirement scenarios	Direction, extent, and severity (how health might be changed, how many are impacted, and ability to mitigate impacts of action)	Likelihood	Distribution (who is impacted)	Quality of evidence
Continued plant operations and release of emissions	▼▼▼▼	Likely	All residents in McCracken and Ballard Counties, particularly vulnerable populations including the young, the elderly, asthmatics, people with heart disease and people of color	***
Implementation of DSI technology	▲▲▲▲	Likely	All residents in McCracken and Ballard Counties, particularly vulnerable populations including the young, the elderly, asthmatics, people with heart disease and people of color	**
Implementation of DSI and additional retrofit technology	▲▲▲▲	Unlikely	All residents in McCracken and Ballard Counties, particularly vulnerable populations including the young, the elderly, asthmatics, people with heart disease and people of color	**
Plant retirement, elimination of emissions	▲▲▲▲	Possible	All residents in McCracken and Ballard Counties, particularly vulnerable populations including the young, the elderly, asthmatics, people with heart disease and people of color	***

Direction, extent, and severity:
Impact on many= ▲▲▲▲ or ▼▼▼▼
Strong impact for few or small impact on many= ▲▲▲ or ▼▼▼
Impact on medium number = ▲▲ or ▼▼
Impact on few= ▲ or ▼
Uncertain= ?
No effect= "no effect" or "none*** many strong studies

Strength/quality of evidence:
*** (e.g., many strong studies)
** (e.g., one or two good studies)
* (e.g., no clear studies, but generally consistent with principles of public health)

Recommendations

Scientists and health researchers have established that air pollution can negatively affect respiratory and cardiovascular health. Currently both McCracken and Ballard Counties have levels of particulate matter, or soot, that can have an impact on health. These communities also have high rates of asthma in both children and adults. Prioritizing air quality in all decision making would help protect the health of some of the community's

most vulnerable populations: those who suffer from asthma, those with cardiac health concerns, the young and the elderly.

While the TVA has shared that the Shawnee Fossil Plant has historically served as a model for available retrofit technology, the plant remains the highest emitter of air pollution in the county, producing 85% of all local TRI releases. New science indicates that stronger regulations are required to protect health from contaminants such as SO2, NOx, ozone, and fine particulate matter. It is expected that continued plant operations with retrofit technology would reduce air pollution. Emissions, however, will not be eliminated entirely.

Recommendations within the context of a retrofit scenario and continued operations:

- Schools and other childcare facilities should track air quality daily through the use of the Air Quality Index and limit children's outdoor activity on bad air days.

The Air Quality Index (AQI), which combines the effects of particulate matter and ozone, is a color coded tool for reporting daily air quality as well as a way to determine what associated health effects may be of concern to different populations. Information on this index can be found at http://airnow.gov/index.cfm?action=aqibasics.aqi.

Schools currently track both weather and heat index in order to inform sports and other outdoor activities. Daily review of the AQI, would further inform how environmental factors may affect children's health. The following is one example of how the AQI's color-coded index might be used:

- On green days it is safe for all children to play outside.
- On yellow days, teachers should be aware of the activities and wellbeing of children identified with extremely sensitive asthma.
- On orange days children identified with asthma should follow any management strategy prescribed by a doctor. This might include taking respiratory treatments prior to outdoor activity, making sure that inhalers are readily available, or potentially restricting outdoor activity time.
- On red days no children will be allowed to play outside as the air is not safe for all populations.

- City and County Planners should encourage private sector developers to find locations for new developments in places that minimize health impacts potentially associated with industrial operations.

Industries that produce soot can impact children and those with respiratory and cardiac health concerns. Locating industries away from places where there are vulnerable populations including schools and nursing homes may help reduce the

concentrations of pollution that can impact their health. The EPA's Risk Screening Environmental Indicators (RSEI) (http://www.epa.gov/opptintr/rsei/index.html) analyzes risk factors to put Toxics Release Inventory (TRI) data into a chronic health context. This ranking system addresses emissions from existing industries and could be used to assess the potential risk of new industries by reviewing data of similar existing plants.

- TVA should consider doing additional retrofits if DSI is insufficient to deal with NOX

Synapse Economics believes that DSI will be insufficient to meet new MATS rules. Retrofits such as ACI, SCR and SNCR may help offset the emissions to safer levels.

Recommendations within the context of a plant retirement scenario:

- TVA should address in the Low Carbon Future Scenario of its Integrated Resource Plan ways in which energy demand no longer met by the Shawnee Fossil plant can be offset through energy efficiency. Such measures can employ local workers while reducing the impact of emissions on public health.

TVA business customers are eligible to take advantage of the new REAP program from the US Department of Agriculture, which is designed to address the needs of rural areas. The REAP Guaranteed Loan Program encourages the commercial financing of renewable energy (bioenergy, geothermal, hydrogen, solar, wind and hydro power) and energy efficiency projects. Under the program, project developers will work with local lenders, who in turn can apply to USDA Rural Development for a loan guarantee up to 85 percent of the loan amount.
(http://www.rurdev.usda.gov/BCP_ReapLoans.html)

While the loan program supports agricultural businesses, it is not limited to agriculture. Borrowers must be an agricultural producer OR rural small business. Agricultural producers must gain 50% or more of their gross income from their agricultural operations. An entity is considered a small business in accordance with the Small Business Administration (SBA) small business size standards NAICS code.(http://www.sba.gov/size/index.html). . Most lenders are eligible, including national and state-chartered banks, Farm Credit System banks and savings and loan associations. Other lenders may be eligible if approved by USDA.

The REAP program is comprised of the following components:

The Renewable Energy System and Energy Efficiency Improvement Guaranteed Loan and Grant Program provides financial assistance to agricultural producers and rural small businesses to purchase, install, and construct renewable energy systems; make energy efficiency improvements; use renewable technologies that reduce energy consumption; and participate in energy audits, renewable energy development assistance, and feasibility studies.

The Energy Audit and Renewable Energy Development Assistance Grant Program provides grant assistance to entities that will assist agriculture producers and small rural businesses by conducting energy audits and providing information on renewable energy development assistance.

The REAP **Energy Audit and Renewable Energy Development Assistance Grant** provides grant assistance to entities that will assist agriculture producers and small rural businesses by conducting energy audits and providing information on renewable energy development assistance. Eligible entities include: State, tribal, local government or their instrumentalities, land grant colleges, universities and other institutions of higher learning, rural electric cooperatives and public power. The maximum amount for an energy audit-renewable energy development assistance grant is $100,000.

Table 21: Summary of Recommendations Addressing Air Quality Factors and Health

Recommendation	Justification	Actor	Sample Strategy
Schools should monitor air quality daily.	On bad air days, McCracken County has levels of air pollution that place sensitive populations at risk.	School administrators	Air quality can be monitored online daily with the AQI. Activities may be determined by the color code of the index.
TVA should consider doing additional retrofits if DSI is insufficient to deal with NOX	DSI may be insufficient to meet new MATS rules.	TVA	Implement ACI, SCR and SNCR
TVA should promote the Energy Efficiency Loan Programs.	Utilization of energy efficiency reduces the need for fuel sources that create air pollution.	TVA	TVA promotes the use of REAP program to customers.
City and county developers should take into account the location of new industries as well as the impact of their potential level of air and water pollution.	Concentrated levels of air pollution can put certain populations at risk to respiratory health concerns.	City Planners, County Planning and Zoning	Assess proposed industries impact on health using RSEI as a point of reference. When zoning for new industries prevent construction near vulnerable populations.

4. Water Quality and Health

Scoping

The Shawnee Fossil Plant draws water from the Ohio River for its operations and produces both dry (80%) and wet ash (20%). The facility releases approximately 20 million gallons of effluent from the wet ash daily into the Ohio River, a common source of both public drinking water and fishing for downstream communities.[cvii] Federal law mandates basic treatment of wastewater before release into local waterways. This involves treatment for suspended solids, pH, oil and grease. There are currently no federal laws requiring treatment of heavy metals. TVA asserts that current methods of settling ponds have been affective at removing metals and suspended solids at their Bull Run Plant. Testing, however, has not yet been carried out to determine any impacts DSI might have on coal ash effluent at the Shawnee Fossil Plant.

Rationale for Inclusion:

Water quality plays an important role in health. Consuming water contaminated with heavy metals can affect the neurologic system as well as increase the risk of certain types of cancers.[cviii] Fish exposed to higher levels of metals in water may bioaccumulate these metals creating an increased risk for humans if the fish is consumed. An additional threat to water quality includes coal ash storage impoundment integrity. Ensuring that coal ash impoundments are sufficiently maintained is critical for protection of surrounding streams and rivers.

Coal ash and effluent management is one of multiple factors TVA must address in either retrofit or retirement scenarios. Implementation of DSI as a retrofit technology will improve air quality and likely associated respiratory and cardiac illnesses. The process may, however, increase the quantity and acidity of coal ash. Lower pH has been identified as a potential concern for water contamination due to increased leaching rates for heavy metals.[cix]

TVA shared that Kentucky Division of Water (KYDOW) requires monitoring on a quarterly basis. This monitoring and reporting includes antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc. KYDOW does not address boron or manganese, other common coal ash contaminants. KYDOW permitting staff evaluate all discharges for reasonable potential to violate current water quality standards in order to maintain designated uses.

In contrast, EPA states that coal based energy production releases over half of all toxic pollutants discharged to surface waters by all industrial categories currently regulated in the US under the Clean Water Act. EPA is currently developing new effluent limitation guidelines for the industry with standards to be introduced in 2015. Presently, permit writers set case-by-case limitations that reflect the best available technology. Due to the various discrepancies and considerations, health impacts of plant effluent are addressed in the HIA.

Arsenic

Arsenic is a naturally-occurring element found in both organic and inorganic forms. Exposure to arsenic though contaminated drinking water at levels above 10 parts per billion can lead to high blood pressure, skin lesions, neurological problems, diabetes and cancers of the lung, bladder, and skin.[cx],[cxi] The MCL for arsenic is .01 mg/L.

Boron

Boron is a naturally-occurring element found in soils, rocks and water. Boron has been shown to leach from coal ash, usually as borate or boric acid.[cxii] While EPA has not required boron to have a Maximum Contamination Level (MCL), it has established the Health Reference Level (HRL) for boron (1.4 mg/L or 1400 µg/L) using the reference dose of 0.2 mg/kg-day. Exposure to boron through water contamination above 3 mg/L a day may have a negative effect on testes including atrophy and spermatogenic arrest. [cxiii]

Selenium

Selenium occurs naturally in rocks in soils and is considered a "coalphile" element, meaning it has a strong attraction to coal. It can be found in both coal and coal ash. Chronic, daily intake of selenium above the MCL can lead to kidney & liver damage, fingernail & hair loss, and damage to the circulatory and nervous systems.[cxiv] The MCL for selenium is .05 mg/L.

Manganese

Manganese is a trace element required by the body in small amounts. Exposure to excess levels of manganese in food, air, or water can damage the brain, nervous, and reproductive systems. There is no enforceable MCL for manganese. However, the drinking water health advisory is .05 mg/L.[cxv]

Bioaccumulation of metals in fish tissue

Bioaccumulation is the build up of metals in tissue resulting from an animal's exposure in its food, water, or environment.[cxvi] Bioaccumulation in fish depends on a wide range of issues including the species, its feeding habits, the concentration of metals in the biota it consumes, food availability, as well as the concentration of metals in water. Humans can be exposed to excess metals when they consume fish out of contaminated bodies of water. While it is difficult to determine concentrations of metals in fish tissue just by testing the water, it is important to understand that the presence of a metal in a body of water may indicate an increased risk. Following fish consumption advisories out of contaminated bodies of water may protect health.

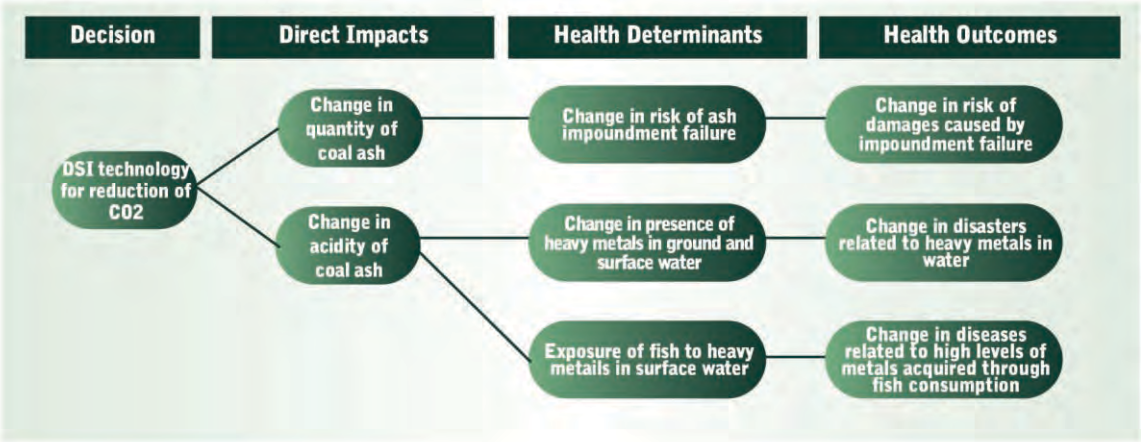
Coal ash impoundment status

Coal ash impoundments and landfills are used to store coal combustion byproducts created in the energy production process. Impoundments that are improperly maintained pose a risk to local bodies of water due to the threat of leaching, leaking, or breakage. Over the past five years, EPA and other contractors have undertaken a concerted effort to identify and to assess the structural integrity of impoundments, ponds, and other management units, within the electric power generating industry, managing wet-handled coal combustion residuals or CCRs. Such measures are critical for safeguarding public health and water quality.[cxvii]

Pathway

Figure 13 shows the pathway relationship between retrofitting the plant to maintain plant operations or plant retirement and associated impacts on water and health.

Figure 13: DSI retrofit: Water quality based health outcomes



Assessment

Dry Sorbent Injection technology's impact on coal ash

Implementation of DSI as a retrofit technology will improve air quality and likely associated respiratory and cardiac illnesses. Previous analysis by Sahu,[cxviii] however, suggests that DSI may increase the quantity and acidity of coal ash. Lower pH has been identified as a potential concern for water contamination due to increased leaching rates of heavy metals.[cxix] No data have yet been collected on the process implemented at the Shawnee Plant to determine if this will be the case. The Shawnee Fossil Plant produces about 600,000 tons of dry coal ash per year. An additional 40,000 tons of bottom ash is wet sluiced to the ash pond where it is dewatered and stacked with the dry ash.[cxx] It is

anticipated that the addition of DSI technology may increase coal ash production 3-6% depending on the sulfur content of the coal burned at the plant.

Ground water and coal ash leachate

Coal ash at the Shawnee Fossil Plant is stored in unlined pits that sit above a number of different aquifers. Discrepancies exist between TVA and other reports on whether or not groundwater has been contaminated and whether or not there is a threat to public health. TVA states that monitoring of groundwater has been ongoing at 14 wells since 1993. During this time no exceedances have been reported to the Kentucky Department of Environmental Protection (KDEP).

In contrast, a review of documents obtained through Freedom of Information Act requests by the Environmental Integrity Project (EIP) reported that groundwater in three aquifers under and around the Shawnee Fossil Plant have been contaminated by coal ash.[cxxi] This report utilizes health-based analyses that are largely not used by KDEP. Analyses included EPA drinking water advisories, child health standards, and some regional screening levels not included in standard Maximum Contaminant Levels (MCLs). These standards, which are not enforceable under federal law, identify concentrations that are thought to pose no risk. Health advisories consider the potential risk based on short-term exposure of children or lifetime exposure to adults for the given contaminant. These health advisories can be especially important to citizens who drink water from private wells. Even though KDEP does not use this system, it does not mean that contamination does not exist.

Monitoring wells included in the EIP study were located outside the boundary of waste management units but were at or inside the perimeter of the power plant or disposal facility. Assessment of public or private water sources was not addressed due to lack of available data and limited monitoring beyond the perimeter of the property.

The report stated:

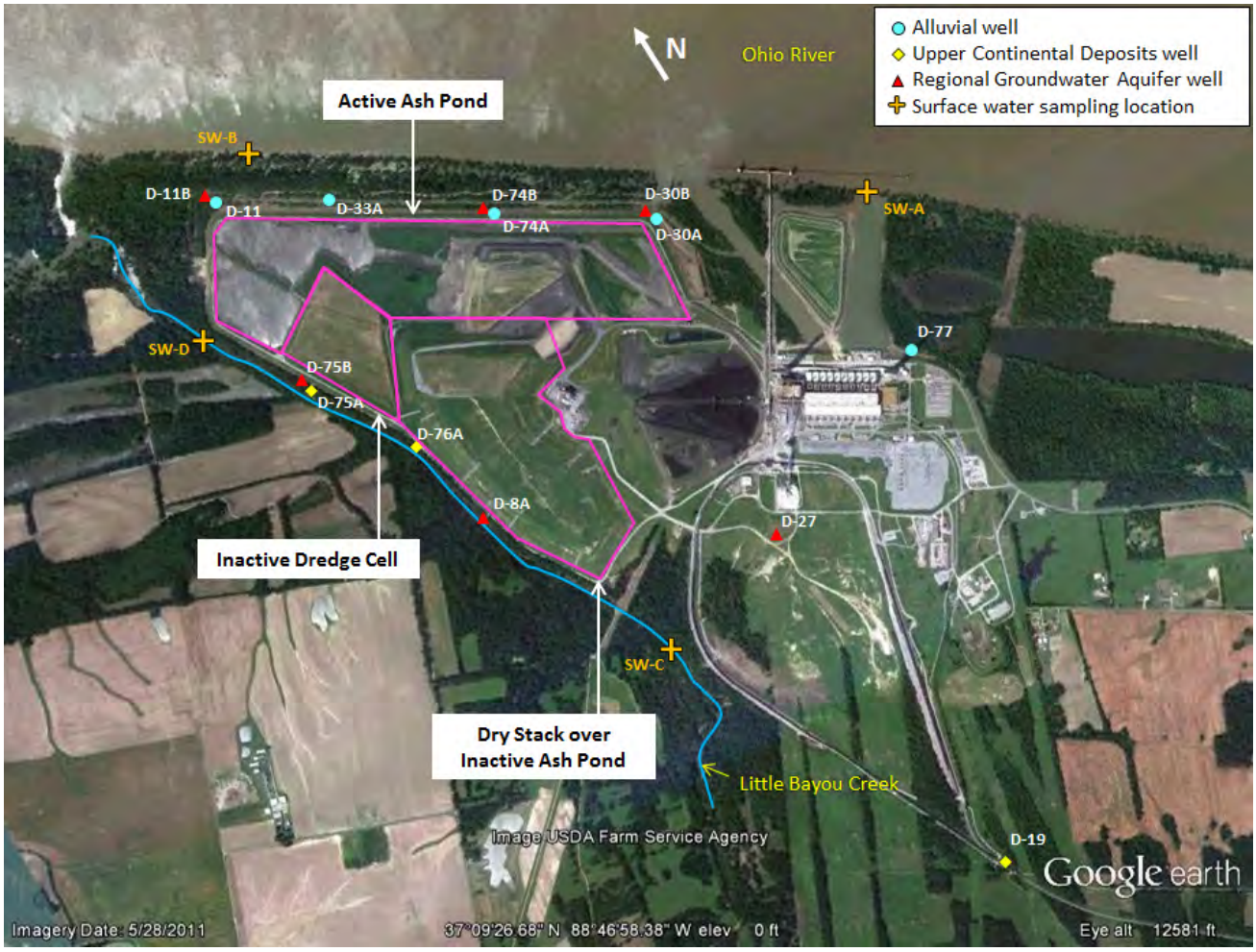
> Three alluvial wells along the Ohio River show high concentrations of boron and manganese; well D-30A also has high levels of cobalt, and well D-74A has high levels of molybdenum. The two down gradient UCD aquifer wells show consistently high boron, manganese, and sulfate; well D-76A has also had high levels of cobalt and molybdenum. All down gradient RGA aquifer wells show high levels of manganese, and three (D-74B, D-30B, and D-75B) have high levels of boron. Well D-75B also exceeded the health-based threshold for cobalt in recent monitoring.

EIP noted that the high levels of manganese were of concern for four reasons:

1. EPA has identified manganese as a coal ash pollutant.
2. There was a clear difference between up gradient and down gradient wells with higher levels down gradient of coal ash storage.
3. Levels of manganese were well above EPA Lifetime Health Advisory levels posing a risk to those who would consume groundwater near the site, and

4. Because Kentucky does not have an MCL for manganese, TVA has not identified or analyzed these exceedances.

Figure 14: Map of Shawnee Fossil Plant showing approximate locations of disposal area, groundwater monitoring wells, and surface water monitoring locations.



In addition, a report from November 2012 by TVA to KDEP[cxxii] notes that "37% compliance sample results fall outside of background testing limits," [sic] and

> *UCD compliance data show the highest statistical exception rate of 55% and include exceptions for boron, TOC, COD, molybdenum, pH, specific conductance, sulfate and TDS. The higher statistical exception rate for the UCD would be expected because this stratum represents the shallowest geologic unit beneath the landfill. RGA data exhibit an exception rate of 42% with exceptions for boron, COD, pH, specific conductance, sulfate and TDS. A statistical exception rate of 22% is noted for samples from the alluvial aquifer with exceptions for boron, TOC, molybdenum, pH, specific conductance and sulfate.*[cxxiii]

These contaminants, especially boron and sulfate, are clear indications of coal ash contamination.

While ground water contamination would primarily be a concern for those consuming well water near plant operations, many community members are now connected to public water systems due to previous ground water contamination of polychlorinated biphenyls (PCBs) by the USEC plant.[cxxiv] The health concern lies in the long-term contamination of ground water for which future landowners must be informed.

Coal ash impoundment status

The EPA has established a hazard rating system that describes the likely consequences of a catastrophic dam failure or misoperation of coal ash impoundments. The ash pond at the Shawnee Fossil Plant has a "Significant" hazard rating meaning that if failure of the impoundment were to occur it would likely cause significant economic loss, environmental damage, or damage to infrastructure. This rating does not address the actual condition of the dam but rather the risk associated with a break. A coal ash impoundment assessment dated June 13, 2013 by the consulting firm, Stantec, rated the structural integrity of the impoundment "satisfactory" and that no additional actions were needed by TVA at this time.

In terms of Kentucky Regulatory Programs requiring the maintenance of dams, deficiencies do exist. The only reporting requirement after dam construction is for certificate renewal every five years. Operators are not given a required inspection frequency and are not required to post a bond to ensure safe operation and maintenance or even completion of dam construction. Finally, Kentucky does not require emergency action planning or inundation mapping. In addition, the state does not require composite liners at all ponds and landfills nor does the state prohibit dumping directly into the water table.[cxxv]

Impoundment failures, such as those that occurred in Kingston TN in 2008 as well as more recently in the winter of 2014 in North Carolina, provide an example of the importance of ensuring that impoundments are structurally sound and not leaking. While the Stantec assessment suggests there is no immediate action required around the maintenance of the ash pond, management of coal ash is a long term investment. Such management should be included in any decision making for both retrofit or retirement scenarios.

Fish consumption advisories

The Kentucky Department of Fish and Wildlife Resources has implemented fish advisories for bodies of water around the Shawnee Fossil Plant. These include Little Bayou Creek, which runs along the southwest of the plant, Metropolis Lake, which lies to the east, and the Ohio River, which runs past the north. PCBs have been found in Little Bayou Creek, likely contaminated by the USEC plant. High levels of mercury have been

observed in fish from Metropolis Lake and the Ohio River. Mercury in fish is commonly the result of power plant emissions.

Fish advisories for these bodies of water range for certain types of fish. Most recommend no more than one to two meals of fish every two months. There are currently no signs indicating fish advisories at Metropolis Lake or at the public pier on the Ohio River near downtown Paducah. Health outcomes from this pathway have a lower magnitude of impact on the community due to the limited number of community members that consume fish from the local bodies of water.

Table 22: Summary of Health Impacts resulting from plant retrofit or retirement scenarios

Scenario	Health factor	Associated health outcomes
Retrofit of plant with DSI and/or additional recommended modifications	Change in acidity and amount of coal ash leading to potential leaching of coal ash into ground water	5Increased risk of exposure to metals in ground water.
Retrofit of plant with DSI and/or additional recommended modifications	Change in acidity and amount of coal ash leading to potential leaching of coal ash into surface water	Increased risk of exposure to metals through consumption of fish in surrounding surface waters
Plant Retirement	Elimination of coal ash production.	Reduced risk of additional ground water contamination. Reduction in risks associated with coal ash management including impoundment failure.

Discussion

As presented in table 23 it is *uncertain* what impact implementation of DSI may have on ground and surface water at the Shawnee Fossil Plant. Research suggests that acidity and quantity of coal ash may change. However, the majority of individuals living near the plant no longer consume ground water due to previous contamination. Long-term concerns could result if future property owners were not aware of the groundwater contamination. Increased contamination of surface waters could potentially affect the bioaccumulation of metals in fish. This could affect the small population of people consuming those fish. Plant retirement would result in a termination of the production of coal ash. While there are no current concerns around the integrity of Shawnee's coal ash impoundment, a reduction in the production of coal ash would reduce the long-term risk of dam failure.

Table 23: Impact Analysis Summary of Findings for Health Determinants Related to Coal Ash and Effluent

Health Determinant: retrofit and retirement scenarios	Direction, extent, and severity (how health might be changed, how many are impacted, and ability to mitigate impacts of action)	Likelihood	Distribution (who is impacted)	Quality of evidence
Implementation of DSI technology: increased risk of metals leaching into ground water	▼	Uncertain	Communities consuming well water in the vicinity of the Shawnee Plant	**
Implementation of DSI technology: increased risk of metals flowing into surface waters	▼▼	Uncertain	Communities consuming fish in waters flowing from the Shawnee Plant	**
Plant retirement: elimination of coal ash production	▲	Uncertain	Communities living down river of the Shawnee Plant that could be impacted by any failure of dam integrity	*

Direction, extent, and severity:
Impact on many= ▲▲▲▲ or ▼▼▼▼
Strong impact for few or small impact on many= ▲▲▲ or ▼▼▼
Impact on medium number = ▲▲ or ▼▼
Impact on few= ▲ or ▼
Uncertain= ?
No effect= "no effect" or "none*** many strong studies

Strength/quality of evidence:
*** (e.g., many strong studies)
** (e.g., one or two good studies)
* (e.g., no clear studies, but generally consistent with principles of public health)

Recommendations

Recommendations within the context of a retrofit scenario:

- TVA should test effluent from the Shawnee plant to determine if additional remediation is required for increased levels of metals potentially leached by the DSI process.

Implementation of DSI as a retrofit technology will improve air quality and likely associated respiratory and cardiac illnesses. The process will, however, increase the quantity and acidity of coal ash. Lower pH has been identified as a potential concern for water contamination due to increased leaching rates of heavy metals.[cxxvi]

Recommendations within the context of both retrofit and retirement scenarios:

- TVA should remediate existing ground water contamination.

Ground water remediation techniques may include bio remediation as well as pump and treat methodology.

- TVA should seek ways to prevent leaching of coal ash into ground water through the lining or relocation of coal ash disposal units.

- TVA should fully disclose levels of contamination to ground water to ensure that current and future local residents do not dig wells to provide water for human consumption.

While ground water contamination would primarily be a concern for those consuming well water near plant operations, many community members are now connected to public water systems due to previous ground water contamination of polychlorinated biphenyls (PCBs) by the USEC plant. The health concern lies in the long-term contamination of ground water for which future landowners must be informed if remediation is not fully implemented.

- TVA should do additional water testing further from the plant property in order to determine the distance that contamination may have traveled.

- TVA should also increase the surface water monitoring in Little Bayou Creek, which has already shown elevated boron concentrations, in order to better characterize the threat to that water body.

- A recommendation is made to TVA to assess drainage pipe integrity and to continue diligence with the assessment of the coal ash dam. In 2013, the company Stantec was contracted to assess coal ash pond No. 2 for structural integrity and leaks. Based on the ratings defined in the USEPA Task Order Performance Work Statement (Satisfactory, Fair, Poor and Unsatisfactory), the information reviewed and the visual inspection, the overall condition of the Ash Pond No. 2 was considered to be satisfactory. Recent coal ash spills in North Carolina, however, bring to light the need for consistent and thorough inspection of drainage pipes at the Shawnee Fossil Plant.

- Signage for Fish Advisories should be located in common fishing areas near the Shawnee Fossil Plant including Metropolis Lake and along public spaces of the Ohio River. These signs should be placed by Kentucky State Nature Preserves.

Recommendations within the context of a retirement scenario:

- 9. TVA should ensure that if the plant is decommissioned, the property is restored to that required of commercial and industrial standards.

Legacy pollution in brown fields can impact public health. Information on current laws and Kentucky's Brownfield Redevelopment Program can be found with the Energy and Environment Cabinet's Department for Environmental Protection: http://waste.ky.gov/sfb/pages/brownfields.aspx

Grants and funding are available for brownfields and land revitalization projects, as well as environmental workforce development and job training through the Environmental Protection Agency. To facilitate the leveraging of public resources, EPA's Brownfields Program collaborates with other EPA programs, other federal partners, and state agencies to identify and make available resources that can be used for brownfields activities.[cxxvii] More information on these grants is available at:
http://www.epa.gov/brownfields/grant_info/

Table 24: Summary of Recommendations Addressing Water Quality Factors and Health

Recommendation	Justification	Actor	Sample strategy
If DSI is installed, do additional metals remediation to ash to reduce leaching.	Health may be impacted by consumption of water contaminated by heavy metals.	TVA	A range of industrial methods exist including the use of flocculants.
Remediate ground water contamination.	Health may be impacted by consumption of contaminated ground water.	TVA	Bio-remediation in conjunction with Pump & Treat system &/or other technologies
Prevent leaching of heavy metals into ground water.	Health may be impacted by consumption of contaminated ground water.	TVA	Line landfills
Disclose contamination to current and future residents.	Health may be impacted by consumption of contaminated ground water.	TVA	Send information regarding contamination to local residents. Information should be noted on property title.
Do additional water testing further from the plant property in order to determine the distance that contamination may have traveled.	Health may be impacted by consumption of contaminated ground water.	TVA	Incorporate independent water sampling of wells outside the property into existing routine water testing.
Increase surface monitoring of Little Bayou Creek.	Surface water contamination increases remediation costs for down stream water treatment facilities.	TVA	Incorporate water sampling of the creek into existing routine water testing.
Assess drainpipe integrity and continue diligence of coal ash dam assessment.	Surface water contamination increases remediation costs for down stream water treatment facilities.	TVA	Incorporate drainpipe assessments into dam assessments.
Proper fish advisory signage should be located at common fishing locations in the community.	Fish in the Ohio River and surrounding lakes are contaminated with mercury. Consumption of contaminated fish can impact public health.	Kentucky State Nature Preserves and the Purchase District Health Department	Signage should be placed at Metropolis Lake and along the Ohio River.
Ensure that if the plant is decommissioned, the property is restored to a fully revitalized state.	Legacy pollution in brown fields can impact public health	TVA	Information on Kentucky Brownfield management can be found through the state's Department for Environmental Protection. Grants and funding for Brownfield and Land Revitalization projects are available through the Environmental Protection Agency.

Conclusion

Conversations around energy production and health are both critical and complex. Just as employment and a strong economy play into social factors of health including access to income for housing, nutrition and health insurance, environmental factors such as air and water quality can affect rates of asthma, heart disease, low birth weight, and cancer. The Health Impact Assessment of the Shawnee Fossil Plant works to outline and identify the range of health outcomes that may be affected through potential retrofit or retirement decisions, and determines recommendations that can help mitigate those concerns.

State and federal regulations are created for the protection of health and the environment. TVA follows such guidelines and works to make changes when new standards are implemented. Though stronger regulations have made great improvements in air quality, not all standards provide complete protection of public health. Air quality standards that utilize three-year averages do not account for days when pollution is higher than average, potentially contributing to increased rates of asthma. Standards addressing the management of coal ash are inconsistent from one state to the next and may not utilize the same set of health-based criteria.

Across the country, power companies are working to determine best next steps for operations in order to both meet new health based guidelines and compete in the shifting energy economy. Prioritizing health in decision-making can and using tools such as HIA, however, make good financial sense. Reducing rates of asthma and heart attacks can lead to significant savings in health care costs. Saving energy through efficiency measures can cut emissions and reduce spending. Long term strategic plans that address both jobs and a healthy environment can ease transitions in employment and lead to stronger, healthier, more sustainable communities.

The Shawnee Fossil Plant Health Impact Assessment and its recommendations are designed to consider such decision making in a holistic manner. By addressing components of each decision as they relate to others, and ensuring that health remains both a visible element and a priority in decision-making, the comprehensive approach may ultimately lead to better health and economic viability for the surrounding community.

Resources

[i] TVA 2015 Integrated Resource Plan. IRPWG Meeting Session (presentation) 2 December 5th, 2013.

[ii] Dupre ME, George LK, Liu G, Peterson ED. The cumulative effect of unemployment on risks for acute myocardial infarction. Arch Intern Med. 2012 Dec 10;172(22):1731-7.

[iii] Colman G, Dave D.Exercise, physical activity, and exertion over the business cycle. Soc Sci Med. 2013 Sep;93:11-20. doi: 10.1016/j.socscimed.2013.05.032. Epub 2013 Jun 13.

[iv] Flint E, Bartley M, Shelton N, Sacker A. Do labour market status transitions predict changes in psychological well-being? J Epidemiol Community Health. 2013 Sep;67(9):796-802. doi: 10.1136/jech-2013-202425. Epub 2013 Jun 28.

[v] Murphy RD, Zemore SE, Mulia N.Housing Instability and Alcohol Problems during the 2007-2009 US Recession: the Moderating Role of Perceived Family Support. J Urban Health. 2013 Jul 30.

[vi] U.S. Census Data. Retrieved July 15, 2013.

[vii] EPA. Mercury and Air Toxics Standards. Cleaner Power Plants. http://www.epa.gov/mats/powerplants.html retrieved February 17, 2014.

[viii] Clifford P. Weisel. Assessing Exposure to Air Toxics Relative to Asthma. *Environmental Health Perspectives.* Vol. 110, Supplement 4 (Aug., 2002), pp. 527-537.

[ix] EPA. Nitrogen Dioxide, Health. Available from: http://www. epa.gov/air/nitrogenoxides/health.html Retrieved: August 15, 2013.

[x] Peters A, Dockery DW, Muller JE, Mittleman MA. Increased particulate air pollution and the triggering of myocardial infarction. Circulation. 2001 Jun 12; 103(23): 2810-5.

[xi] Brook RD, Rajagopalan. Particulate matter air pollution and atherosclerosis. Current Atherosclerosis Reports, 2010 Sep; 12(5): 291-300.

[xii] Wellenius GA, Schwartz J, Mittleman MA. Air pollution and hospital admissions for ischemic and hemorrhagic stroke among Medicare beneficiaries. Stroke, 2005 Dec; 36(12): 2549-53. Epub 2005 Oct 27.

[xiii] Moulton PV, Yang W. Air pollution, oxidative stress, and Alzheimer's disease. Journal of Environ Public Health. Epub 2012 Mar 15.

[xiv] Ji M, Cohan DS, Bell ML. Meta-analysis of the Association between Short-Term Exposure to Ambient Ozone and Respiratory Hospital Admissions. Environmental Research Letters, 2011 Apr;6(2). pii: 024006.

[xv] Department of Health and Human Services. Healthy People 2020. http://www.healthypeople.gov/2020/topicsobjectives2020/nationaldata.aspx?topicId=21 Accessed February 8, 2014.

[xvi] Kentucky Department of Public Health. Asthma Facts 2012. http://www.cdc.gov/asthma/faqs.htm retrieved May 2, 2014.

[xvii] Sahu, R. Technical Report on Dry Sorbent Injection (DSI) and Its Applicability to TVA's Shawnee Fossil Plant (SHF). Commissioned by the Southern Alliance for Clean Energy. April 2013.

[xviii] Environmental Integrity Project. TVA's Toxic Legacy: Groundwater Contaminated by Tennessee

Valley Authority Coal Ash. November 2013. http://www.environmentalintegrity.org/news_reports/documents/20131107_tvagroundwaterreport_fulldraft_000.pdf

[xix] Myers, J. TVA Correspondence. December 9 2013.

[xxi] TVA. Integrated Resource Plant. http://www.tva.com/environment/reports/irp/ retrieved July 17, 2014.

[xxii] TVA 2015 Integrated Resource Plan. IRPWG Meeting Session (presentation) 2 December 5th, 2013.

[xxiii] National Research Council, Committee on Health Impact Assessment. Improving Health in the United States: The Role of Health Impact Assessment. 2011

[xxiv] "Paducah Power plan proposes two more home rate increases," Paducah Sun, March 15, 2013

[xxv]EPA. Risk Screening Environmental Indicators. http://oaspub.epa.gov/enviro/rsei.html?facid=42086STVSH7900M retrieved April 10, 2014.

[xxvi] EPA. Children's Environmental Health Disparities, Black and African American Children and Asthma. http://www.epa.gov/epahome/sciencenb/asthma/HD_AA_Asthma.pdf retrieved August 11, 2014.

[xxvii] S. Smith et al. Discovering the Full Spectrum of Cardiovascular Disease, Minority Health Summit. Circulation. 2005; 111: e134-e139

[xxviii] CDC. Older Persons Health. http://www.cdc.gov/nchs/fastats/older-american-health.htm retrieved August 11, 2014.

[xxix] Leung CW, Epel ES, Ritchie LD, Crawford PB, Laraia BA.J Food Insecurity Is Inversely Associated with Diet Quality of Lower-Income Adults. Acad Nutr Diet. 2014 Aug 1. pii: S2212-2672(14)01022-3. doi: 10.1016/j.jand.2014.06.353. [Epub ahead of print]

[xxx] US Census. McCracken County, KY. http://quickfacts.census.gov/qfd/states/21/21145.html retrieved August 11, 2014.

[xxxi] US Census. Ballard County, KY. http://quickfacts.census.gov/qfd/states/21/21007.html retrieved August 11, 2014.

[xxxii] US Census. Paducah, Kentucky http://quickfacts.census.gov/qfd/states/21/2158836.html retrieved July 17, 2014.

[xxxiii] County Health Rankings. University of Wisconsin Population Health Institute. http://www.countyhealthrankings.org/credits

[xxxiv] Kentucky Health Facts. http://www.kentuckyhealthfacts.org/ retrieved May 2, 2014.

[xxxv] Kentucky Department of Health. http://www.kentuckyhealthfacts.org/data/location/ retrieved May 2, 2014.

[xxxvi] CDC. Healthy people 2020. http://www.healthypeople.gov/2020/data/searchData.aspx retrieved May 2, 2014.

[xxxvii] Paneth NS. The problem of low birth weight. Future Child. 1995;5:19-34.

[xxxviii] Dadvand P, Parker J, Bell M, Bonzini M, Brauer M, Darrow L, et al. Maternal Exposure to Particulate Air Pollution and Term Birth Weight: A Multi-Country Evaluation of Effect and Heterogeneity.

Environmental Health Perspectives. 02/2013

[xxxix] Kentucky State Data Center. Kentucky Department for Public Health Office of Vital Statistics via KentuckyHealthFacts.org. Accessed February 8, 2014.

[xl] Department of Health and Human Services. Healthy People 2020. http://www.healthypeople.gov/2020/topicsobjectives2020/nationaldata.aspx?topicId=21 retrieved February 8, 2014.

[xli] Zanobetti A, Schwartz J. The effect of particulate air pollution on emergency admissions for myocardial infarction: a multicity case-crossover analysis. Environ Health Perspective. 2005 Aug;113(8):978-82.

[xlii] Kentucky Department of Public Health. Asthma Facts 2012. http://www.cdc.gov/asthma/faqs.htm retrieved May 2, 2014.

[xliii] CDC. Asthma. http://www.cdc.gov/asthma/faqs.htm retrieved May 2, 2014.

[xlv] Doll R. Epidemiological evidence of the effects of behaviour and the environment on the risk of human cancer. Recent Results Cancer Res. 1998;154:3-21.

[xlvi] Wellenius GA, Schwartz J, Mittleman MA. Air pollution and hospital admissions for ischemic and hemorrhagic stroke among medicare beneficiaries. Stroke, 2005 Dec; 36(12): 2549-53. Epub 2005 Oct 27.

[xlvii] EPA. Arsenic Compounds. http://www.epa.gov/ttn/atw/hlthef/arsenic.html retrieved July 17, 2014.

[xlviii] Dupre ME, George LK, Liu G, Peterson ED. The cumulative effect of unemployment on risks for acute myocardial infarction. Arch Intern Med. 2012 Dec 10;172(22):1731-7.

[xlix] Colman G, Dave D.Exercise, physical activity, and exertion over the business cycle. Soc Sci Med. 2013 Sep;93:11-20. doi: 10.1016/j.socscimed.2013.05.032. Epub 2013 Jun 13.

[l] Flint E, Bartley M, Shelton N, Sacker A. Do labour market status transitions predict changes in psychological well-being? J Epidemiol Community Health. 2013 Sep;67(9):796-802. doi: 10.1136/jech-2013-202425. Epub 2013 Jun 28.

[li] Murphy RD, Zemore SE, Mulia N.Housing Instability and Alcohol Problems during the 2007-2009 US Recession: the Moderating Role of Perceived Family Support. J Urban Health. 2013 Jul 30.

[lii] Burke C, Johnson EE, Bourgault C, Borgia M, O'Toole TP.Losing work: regional unemployment and its effect on homeless demographic characteristics, needs, and health care. J Health Care Poor Underserved. 2013;24(3):1391-402.

[liii] Sverke M, Hellgren J, Näswall K. No security: a meta-analysis and review of job insecurity and its consequences. J Occup Health Psychol. 2002 Jul;7(3):242-64.
[liv] Brooks-Gunn J, Duncan GJ. The effects of poverty on children. Future Child. 1997;7(2):55-71.

[lv] Aber JL, Bennett NG, Conley DC, Li JL. The effects of poverty on child health and development. Annual Rev Public Health. 1997;18:463-483.

[lvi] U.S. Census Data. http://quickfacts.census.gov/qfd/states/21/21145.html retrieved October 29, 2013.

[lvii] Fronstin P. Sources of Health Insurance and Characteristics of the Uninsured: Analysis of the March 2009 Current Population Survey. Employee Benefit Research Institute; 2009. EBRI Issue Brief no. 334.

[lviii] County Health Rankings. Access to care. http://www.countyhealthrankings.org/our-approach/health-factors/access-care retrieved May 2, 2014.

[lix] Institute of Medicine. Hidden Costs, Value Lost: Uninsurance in America. Washington, DC: Institute of Medicine;2003.

[lx] Id. Murphy.

[lxi] Id. Colman.

[lxii] Id. Flint.

[lxiii] Mandal B, Roe B.Job loss, retirement and the mental health of older Americans. J Ment Health Policy Econ. 2008 Dec;11(4):167-76.

[lxiv] Id. Dupre.

[lxv]Navigant Research. Coal Plant Decommissioning report. http://www.navigantresearch.com/research/coal-plant-decommissioning retrieved May 10, 2014

[lxvi] U.S. Census Data. Retrieved July 15, 2013.

[lxvii] Id. Doyle C. March 2005.

[lxviii] Schillinger D, et al. Does literacy mediate the relationship between education and health outcomes? A Study of a Low-Income Population with Diabetes. Public Health Rep. 2006 May-Jun; 121(3): 245-254.

[lxix] Muller A. Education, income inequality, and mortality: a multiple regression analysis. BMJ. 2002 Jan 5;324(7328):23-5.

[lxx] Kilander L, Berglund L, Boberg M, Vessby B, Lithell H. Education, lifestyle factors and mortality from cardiovascular disease and cancer. A 25-year follow-up of Swedish 50-year-old men. Int J Epidemiol. 2001 Oct;30(5):1119-26.

[lxxi] Cutler D, Lleras-Muney A. Education and Health: Evaluating Theories and Evidence. Cambridge, MA: National Bureau of Economic Research; 2006. Working Paper Series, no. 12352.

[lxxii] Mustard CA, Derksen S, Berthelot JM, Wolfson M, Roos LL. Age-specific education and income gradients in morbidity and mortality in a Canadian province. Soc Sci Med. 1997 Aug;45(3):383-97.

[lxxiii] Miech R, Pampel F, Kim J, Rogers R. The Enduring Association between Education and Mortality: The Role of Widening and Narrowing Disparities. American Sociological Review. December 2011; vol. 76, 6: pp. 913-934.

[lxxiv] U.S. Department of Justice, Office of Community Oriented Policing Services (the COPS Office). The Impact of the Economic Downturn on American Police Agencies. October 2011.

[lxxv] Elvik R. Speed limits, enforcement, and health consequences. Annu Rev Public Health. 2012 Apr;33:225-38. Epub 2012 Jan 3.

[lxxvi]U.S. Fire Administration Funding Alternatives for Emergency Medical and Fire Services. FA-331/April 2012 http://www.usfa.fema.gov/downloads/pdf/publications/fa_331.pdf retrieved August 18, 2014.

[lxxvii] Bettinelli A, Cordone R, Ficarelli F, Righini G.J Emerg Manag. Simulation and optimization models for emergency medical systems planning. 2014 Jul-Aug;12(4):287-301.

[lxxviii] EPA. National Ambient Air Quality Standards. http://www.epa.gov/air/criteria.html. retrieved April 7, 2014.

[lxxix] Ji M, Cohan DS, Bell ML. Meta-analysis of the Association between Short-Term Exposure to Ambient Ozone and Respiratory Hospital Admissions. Environmental Research Letters, 2011 Apr;6(2). pii: 024006.

[lxxx] Peters A, Dockery DW, Muller JE, Mittleman MA. Increased particulate air pollution and the triggering of myocardial infarction. Circulation. 2001 Jun 12; 103(23): 2810-5.

[lxxxi]Wellenius GA, Schwartz J, Mittleman MA. Air pollution and hospital admissions for ischemic and hemorrhagic stroke among medicare beneficiaries. Stroke, 2005 Dec; 36(12): 2549-53. Epub 2005 Oct 27.

[lxxxii] Slama R, Morgenstern V, Cyrys J, Zutavern A, Herbarth O, Wichmann HE, Heinrich J; LISA Study Group. Traffic-related atmospheric pollutants levels during pregnancy and offspring's term birth weight: a study relying on a land-use regression exposure model. Environmental Health Perspectives, 2007 Sep; 115(9): 1283-92.

[lxxxiii] Moulton PV, Yang W. Air pollution, oxidative stress, and Alzheimer's disease. Journal of Environ Public Health. Epub 2012 Mar 15.

[lxxxiv] Ji M, Cohan DS, Bell ML. Meta-analysis of the Association between Short-Term Exposure to Ambient Ozone and Respiratory Hospital Admissions. Environmental Research Letters, 2011 Apr;6(2). pii: 024006.

[lxxxv] EPA.

[lxxxvi] Sahu, Ranajit. Dry Sorbent Injection (DSI) and Its Applicability to TVA's Shawnee Fossil Plant (SHF). April 2013.

[lxxxvii] Myers, J. TVA Correspondence. December 9 2013.

[lxxxviii] EPA. Sulfur Dioxide. http://www.epa.gov/airquality/sulfurdioxide/health.html retrieved July 24, 2013.

[lxxxix] Sierra Club Evaluation of Compliance with 1-hour SO2 NAAQS August 8, 2012

[xc] U.S. Department of Health and Human Services. http://minorityhealth.hhs.gov/templates/content.aspx?ID=6170. retrieved May 2, 2014.

[xci] EPA. Nitrogen Dioxide. http://www.epa.gov/airtrends/aqtrnd95/no2.html retrieved May 2, 2014.

[xcii] U.S. EPA. Nitrogen Oxide: Health. http://www.epa.gov/oaqps001/nitrogenoxides/health.html retrieved October 7, 2013.

[xciii] TVA. Shawnee Fossil Plant Emissions. http://www.tva.com/environment/air/shawnee.htm retrieved May 2, 2014.

[xciv] EPA. Criteria Pollutants. http://www.epa.gov/air/criteria.html retrieved February 22, 2014.

[xcv] American Lung Association. State of the Air, 2014. www.stateoftheair.org retrieved May 2, 2014.

[xcvi] Peters A, Dockery DW, Muller JE, Mittleman MA. Increased particulate air pollution and the triggering of myocardial infarction. Circulation. 2001 Jun 12; 103(23): 2810-5.

[xcvii] Wellenius GA, Schwartz J, Mittleman MA. Air pollution and hospital admissions for ischemic and hemorrhagic stroke among medicare beneficiaries. Stroke, 2005 Dec; 36(12): 2549-53. Epub 2005 Oct 27.

[xcviii] County Health Rankings. Air Pollution- Particulate Matter. http://www.countyhealthrankings.org/app/kentucky/2014/measure/factors/125/map

[xcix] EPA Office of Air Quality Planning & Standards and Office or Research And Development. Mercury study report to Congress. Volume II: and inventory of anthropogenic mercury emissions in the U.S. Dec 1997: EPA-452/R-97-004.

[c] Davis, D. When Smoke Ran Like Water: Tales of environmental deception and the battle against pollution. New York: Basic Books. 2002.

[ci] Trasande L, Schechter CB, Haynes KA, Landrigan PJ. Mental retardation and prenatal methyl mercury toxicity. Am J Ind Med. 2006 Mar; 49(3):153-8.

[cii] World Health Organization. Climate Change and Health Fact Sheet. http://www.who.int/mediacentre/factsheets/fs266/en/ retrieved July 24, 2013.

[ciii] Brownstein J, Holford T, and Fish D. Effect of Climate Change on Lyme Disease Risk in North America. Ecohealth. 2005 March; 2(1): 38–46.

[civ] Environmental Integrity Project. Net Loss: comparing the Cost of Pollution vs. the Value of Electricity from 51 Coal-Fired Plants. June 2012 http://www.environmentalintegrity.org/news_reports/documents/PowerPlantReport.pdf

[cv] Brook R. et al. Particulate Matter Air Pollution and Cardiovascular Disease. AHA Scientific Statement. http://circ.ahajournals.org/content/121/21/2331.full retrieved August 21, 2014.

[cvi] Kentucky Traffic Collision Facts, 2014. http://www.kentuckystatepolice.org/pdf/KY_Traffic_Collision_Facts_2012.pdf.

[cvii] Kentucky Department for Environmental Protection, Pollutant Discharge Elimination System Permit No . KY0004219 (July 13, 2005)

[cviii] EPA. Drinking Water Contaminants. http://water.epa.gov/drink/contaminants/ retrieved July 7, 2014.

[cix] Id Sahu.

[cx] Rahman, Mohammad Mahmudur, Jack C. Ng, and Ravi Naidu
2009 Chronic Exposure of Arsenic via Drinking Water and Its Adverse Health Impacts on Humans. Environmental Geochemistry and Health 31(1): 189–200.

[cxi] Abernathy, C O, Y P Liu, D Longfellow, et al.
1999 Arsenic: Health Effects, Mechanisms of Actions, and Research Issues. Environmental Health Perspectives 107(7): 593–597.

[cxii] Cox, James A., Gary L. Lundquist, Andrzej Przyjazny, and C. David Schmulbach
1978 Leaching of Boron from Coal Ash. Environmental Science & Technology 12(6): 722–723.

[cxiii] EPA. Health Effects Support Document for Boron. EPA Document Number EPA-822-R-08-002 January, 2008.

[cxiv] EPA N.d. Fact SheetTechnical Factsheet on: SELENIUM. http://www.epa.gov/safewater/pdfs/factsheets/ioc/tech/selenium.pdf.

[cxv]ATSDR. Manganese. http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=101&tid=23 retrieved August 18, 2014.

[cxvi] Drexler. J., N. Fisher, G Hennington, R Lanno, J McGeer, K Sappington, M Beringer. Issue paper on the bioavailability and bioaccumulation of metals. Draft. Prepared for the EPA. August 2003. http://www.epa.gov/raf/publications/pdfs/BIOAVAIL_BIOACCUM_AUG03.PDF

[cxvii] EPA. Coal Combustion Residuals (CCR) - Surface Impoundments with High Hazard Potential Ratings http://www.epa.gov/solidwaste/nonhaz/industrial/special/fossil/ccrs-fs/index.htm retrieved August 18, 2014.

[cxviii] Id Sahu.

[cxix] Id Sahu.

[cxx] Stantec. TVA Disposal Facility Assessment Phase 1 Plant Summary Shawnee Fossil Plant (SHF) http://www.tva.com/power/stantec/ky/rpt_005_appndx_c_shf_171468118.pdf

[cxxi] Environmental Integrity Project. TVA's Toxic Legacy: Groundwater Contaminated by Tennessee Valley Authority Coal Ash. November 2013. http://www.environmentalintegrity.org/news_reports/documents/20131107_tvagroundwaterreport_fulldraft_000.pdf

[cxxii] Document A72 121221 001 Env. Document Type: Groundwater, Report from TVA to Kentucky Division of Waste Management. Dec. 20, 2012. http://www.tva.gov/foia/readroom/frequent/groundwater/Shawnee%20Fossil%20Plant/SHF%202nd%20half%20year%20GWA%20and%20Surface%20Water%20Rpt%20cover%20ltr%20and%20re.pdf

[cxxiii] Id. Report by TVA to KDWM. 2012

[cxxiv] Paducah Sun. "Landowners settle suit over plant pollution." April 21, 2010.

[cxxv] Id. EIP

[cxxvi] Id Sahu.

[cxxvii] EPA Brownfields and Land Revitalization Grants & Cleanup Funding: http://www.epa.gov/brownfields/grant_info/index.htm