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Answers in the East: An Examination of China's Renewable Energy and its Application to Central Appalachia

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ANSWERS IN THE EAST: AN EXAMINATION OF CHINA'S RENEWABLE ENERGY AND ITS APPLICATION TO CENTRAL APPALACHIA

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ABSTRACT

While much of China's electrification has depended on coal, recent decades illustrate the country is heavily investing in and implementing renewable energy as a power source. Even China's coal-rich provinces, like the northeastern province of Shanxi, have been making the transition to renewable energy. The central Appalachian states comprised of eastern Kentucky, West Virginia, western Virginia, and northeastern Tennessee share many characteristics with China's Shanxi province including economic resources, climate, and geography. Yet, central Appalachia has not been able to easily transition to renewable energy. However, there are various cultural, political, and technological differences between the two regions to explain this. This analysis aims to illustrate the methods and policies that China has implemented to create a market conducive to renewable energy and to suggest the applications these methods and policies have to central Appalachia. Specifically, renewable energy could assist in poverty alleviation in central Appalachia through economic revitalization in addition to remediating environmental hazards associated with coal mining.

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INTRODUCTION

During the initiation of China's Communist Party in 1949, rural electrification became a prominent issue. As the population continued to grow, so did the demand for energy which caused a transformation of China's power sector. This is where the first appearance of China's five-year plans, used to anticipate changes in the economy and energy demands, can be seen. Coal became an invaluable resource to provide electricity to all of China's citizens (Meisen and Cavino, 2007).

The use of coal in China has created a plethora of issues including air-pollution-related health impacts, more extreme weather phenomena related to rising atmospheric carbon dioxide levels, and contamination of water supplies (Layke, 2019). Reducing the impacts of climate change has been of utmost importance in recent years, but to curb rising global temperatures, the use of carbon-emitting fossil fuels needs to drastically decrease. Yet, China remains the largest producer and consumer of coal in the world. In 2019, China produced 3,693 megatons of coal and consumed 53% of the global share of coal that year (International Energy Agency, 2020). This is further exemplified in Figure 1 as China's primary energy consumption in 2018 and the majority of total installed energy capacity in 2019 are both coal-dominated.

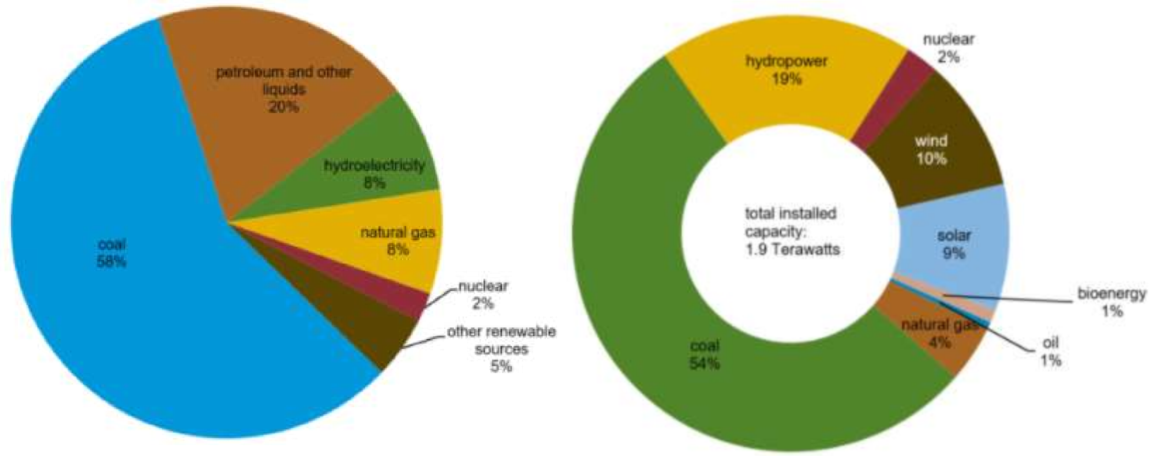

Figure 1 – (Left) China's energy consumption in 2018, (Right) China's installed energy capacity in 2019 (U.S. Energy and Information Administration).

China's population has suffered from adverse health consequences directly related to burning coal. Air pollution in cities like Beijing and Chengdu caused by the burning of coal has led to long-term health problems and hundreds of thousands of premature deaths, with an estimated annual death toll of over 250,000 in China (Burt, Orris, and Buchanan, 2013).

In some areas of China, coal has been mineralized with toxic trace elements such as arsenic and fluorine. In rural regions, this coal is burned in unventilated stoves that volatilize the elements which are then breathed in by the users. Issues have even been discovered with food that is dried by this coal, particularly chili peppers. Chili peppers from Guizhou have been found with over 500 ppm of arsenic (Finklemen, Belkin and Zheng, 1999). Those suffering from chronic arsenic exposure exhibit many visible signs like hyperkeratosis – thickening of the outer layer of skin, hyperpigmentation – darkening of certain areas of the skin, and squamous cell carcinoma – a potentially fatal form of skin cancer.

Fluorosis is an even more widespread side-effect of burning mineralized coal, affecting several million people throughout China. Common symptoms of fluorosis include mottling of tooth enamel and various other skeletal issues such as osteosclerosis, spinal curvature, and knock knees, all of which can severely limit mobility (Finklemen, Belkin and Zheng, 1999).

To curb these issues and diversify its economy China has made an enormous transition to renewable energy. Even coal-rich provinces in China (Figure 2) have taken measures to reduce their carbon emissions and transition to renewable energy.

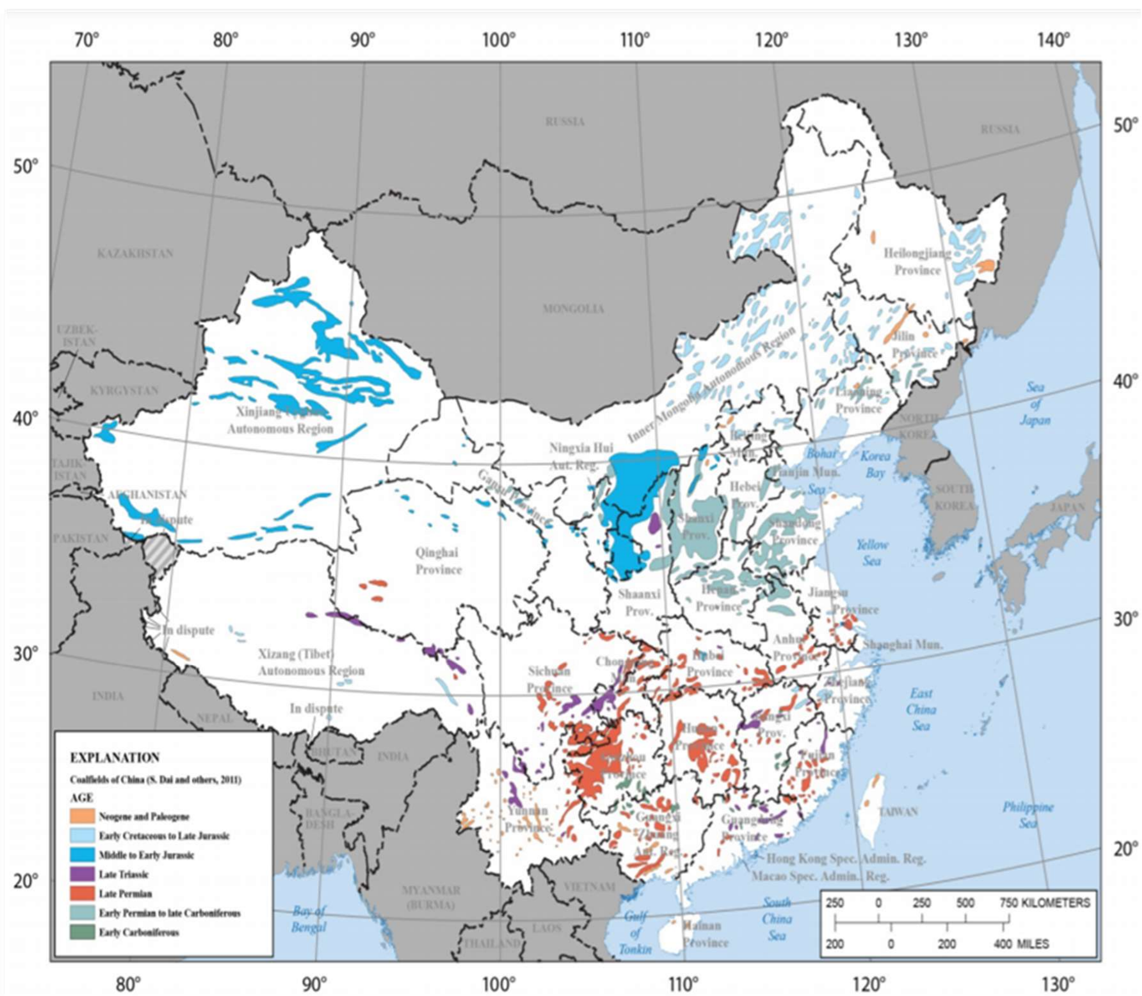

Figure 2 - Coal fields across Chinese provinces (Trippi, et. al., 2014).

The United States, while a much younger country, began industrialization in the 1790s, several decades before China began significant industrialization in the 1950s (Xiaoyun, 2014). As such, the history of coal use in the United States is more extensive. After the colonies became independent of Britain, the states had to utilize domestic energy sources rather than rely on imports. The Richmond Basin in Virginia became one of the first major sources of domestic coal (Adams, 2020).

The Antebellum Era of the early 1800s brought the largest expansion of the coal industry as mines opened across several states from Ohio to Pennsylvania. The coal extracted in these mines helped fuel America's industrialization. Then, in 1861 the American Civil War further increased the demand for coal as both the Union and Confederacy needed coal to fuel their wartime operations. The expansion of railroad systems further increased access to coal across the country (Adams, 2020).

At the start of the 20th century, the popularity of coal began to decline as concerns over environmental issues rose, thus the popularity of oil and natural gas began to rise. This changed when in 1973 the Arab members of the Organization of Petroleum Exporting Countries (OPEC) placed an oil embargo on the United States due to the U.S. government's support of the Israeli military (Office of the Historian, 2021). Consequently, supplies of oil in the United States plummeted while prices soared. Then-President Richard Nixon declared the need for energy independence so that the United States would no longer have to rely on foreign countries for energy, and thus began Project Independence. This brought coal back to the forefront as a reliable energy resource (Office of the Historian, 2021).

Coal mining and use is not without consequence in the United States. Much like China, coal creates lasting impacts on human health. In the Appalachian region, the method of coal mining may cause just as much harm as burning the coal itself. Mountaintop removal mining (MTRM) is a method of coal mining that quite literally removes the top of a mountain to access coal seams beneath. The resulting dust and subsequent processing of the mined coal causes adverse health effects (Palmer, et. al., 2010).

Indiana University Professor Michael Hyndryx (2020) states that studies done in Appalachia, even when accounting for confounding factors such as poverty and smoking, found that there are 1,200 excess deaths annually of people who live in MTRM communities versus those who do not. Common illnesses in these communities include lung cancer, cardiovascular disease, and chronic obstructive pulmonary disease. Ultra-fine particulate matter, such as tin, aluminum, and silica, could contribute to these health risks as the small size of the particles can enter the lungs and travel almost anywhere in the body. The rate of birth defects was also elevated in these areas. In fact, the risk of heart defects was found to be 181% higher in these mining communities versus elsewhere. (Schiffman, 2017).

Much of mountaintop removal is centered in the central Appalachian states of Kentucky, West Virginia, Virginia, and Tennessee and this method has yet to gain much popularity elsewhere for coal mining. This is because central Appalachia has been so heavily mined that easily accessible coal seams are scarce. Plus, mountain top removal allows almost complete recovery of available coal with less manpower. As a result, it is estimated that roughly 21,000 acres of land each year (from 1985 – 2015) in mountaintop removal areas are reduced to bare Earth (Smith, 2018). China still uses the more traditional methods of surface and deep mining.

Central Appalachia is reminiscent of one of China's top coal-producing provinces, Shanxi. Both regions are approximately the same geographic size, and both are located at almost the same latitude line at 37 degrees, so their climates are also similar. More importantly, both have relied on fossil fuels for electrification and as an economic resource. However, Shanxi has been able to make significant progress towards transitioning to renewable energy while much of central Appalachia has not.

ENERGY SECTORS AND RENEWABLE ENERGY POLICY

China's Energy Sector

While China has a communist government, the nature of its economy is more complicated with experts arguing that it has leaned more towards capitalism and others arguing it is a strictly socialist economy (Bris and Greeven, 2020). The energy sector reflects this ongoing debate as it has undergone several fluctuations in control over the decades. Periods of governmental centralization have been followed by decentralization and diversification of the industry. So, while the Chinese government still exerts control over the sector, provinces have gained a significant amount of autonomy in the day-to-day decision-making related to energy consumption and production (Meisen and Cavino, 2007).

Decisions regarding China's economic and social development are outlined in their comprehensive five-year plans, which have come to include plans for developing renewable energy resources. In 2016, China released its 13th five-year plan. While these plans often have a qualitative approach rather than quantitative, it allows provinces to formulate their own more specific targets. Some examples of these qualitative goals include: active and steady development of hydropower, promoting the use and diversification of solar power, and accelerating the development of biomass power (National Development and Reform Commission, 2016).

In late 2020 the government convened to discuss and draft China's 14th five-year plan which was then approved in March of 2021. In terms of sustainability China will be focusing on its commitment to reduce peak carbon levels before 2030 and carbon neutrality before 2060. This will involve taking steps to ensure a carbon cap for the power sector, reduction of fine particle pollution across key cities, and greater forest coverage (Yixiu and Zhe, 2021). Ensuring greater forest coverage will be particularly important to replenish the forests that were harvested for Mao Zedong's industrialization efforts during the "Great Leap Forward" (1958 – 1962) which consequently caused environmental issues. The water retention capacity and the porosity of the soil were both altered, allowing wind to transport it elsewhere (Steinfeld, 2018). However, China has also indicated in their 14th five-year plan that they want to become more self-sufficient and focus on domestic needs, meaning that future research and trade with the United States may become even more difficult (Mallapaty, 2021).

United States' Energy Sector

The United States does not seem to have a continually updated energy plan comparable to China's five-year plans. While some federal regulations are in place, states still hold much of the power in dictating how to produce and consume their energy. Because of this, a cohesive outline of green energy goals for the country is not in place.

While the United States is not known as a champion for renewable energy resources, which is evident by not partaking in the Kyoto Protocol and withdrawing from the Paris Climate Agreement (which the United States rejoined in 2021), the use of renewable energy in the United States has continued to grow. However, this growth has not been distributed equally across the country. Much of the growth is centered in the western portion of the country with states such as California, Texas, Washington, and Oregon producing the largest amounts of renewable energy (U.S. Energy Information Administration, 2020).

This reflects the power that the states hold in making decisions regarding their energy usage. At the state level, as of 2020, it was found that 37 states along with Washington D.C. and 4 U.S. territories had renewable portfolios in place (Center for Sustainable Systems, 2020). With no central goals across the nation these state plans could vary widely with little to no accountability in place for achieving said goals.

China's Economic Policy Regarding Renewable Energy

There is no doubt that China's economic incentives have helped create a blossoming market for renewable energy. A major economic contributor is feed-in tariffs (FITs). FITs promote the growth of renewable energy by giving small-scale producers above-market prices for what they provide to the electric grid and they also involve long-term contracts ranging anywhere from ten to twenty-five years. FITs are generally most advantageous during the earlier stage of investment and production when renewable energy is less economically viable (Cox and Esterly, 2016).

While FITs remain a hallmark of renewable energy policy in China, there have been fluctuations in the use of FITs in China in recent years. Currently, the use of FITs is on the decline due to growing deficits in funds used to pay for subsidies that are derived from electricity surcharges. It remains a struggle to constantly adjust prices based on fluctuating market costs. This has directly contributed to an overall total drop in solar installations in China (Oxford Institute for Energy Studies, 2020).

A nationwide net metering policy was also introduced in 2013 to help drive consumer incentives for solar power. This policy compensates consumers who produce excess energy from solar panel systems which is then sent back into the electric grid for use. The effectiveness of net metering was found to vary by solar radiation differences as well as electricity demand differences between regions (Jia et al., 2020).

The United States' Economic Policy Regarding Renewable Energy

The United States federal government does provide some incentives for utilizing renewable energy the most prominent of which is the Investment Tax Credit. The Investment Tax Credit can help decrease the initial cost of implementing renewable technology up to 26%, and it encourages both residential and commercial investment in renewables. Like China, the United States has implemented some feed-in tariffs on a state level. The United States also uses net metering as a practice to reward consumers for producing excess energy from renewable energy systems. Unlike China, the use of net metering in the United States dates to the 1980s.

Poverty Alleviation in China

Besides the benefit of reducing the country's carbon footprint, China has recognized that ensuring access to electricity can help alleviate poverty. Several projects have been initiated with this specific goal in mind. The Solar Energy for Poverty Alleviation Program (SEPAP) was created in 2013 to reduce poverty specifically in rural areas. Studies have shown this program to be successful with an overall increase in per-capita disposable income by 7-8% in the counties where the program is implemented, and the effects were even stronger in poorer counties (Zhang et al., 2020).

Even before SEPAP, China introduced the Brightness Program in 1996 to target electrification of rural areas such as Mongolia and Tibet using renewable energy, and by the end of the first part of the project had, "Installed 1,780,000 household systems, 2000 village systems, and 200 station systems," (National Renewable Energy Laboratory, 2004, p.1). Thus, China has demonstrated that an effective method of poverty alleviation in rural areas lies in utilizing renewable energy.

CHINA'S SHANXI (山西) PROVINCE AND CENTRAL APPALACHIA

For comparison with central Appalachian states, the province of Shanxi located in the northern part of China is examined. Roughly over 155,400 km^2 in area (roughly 60,000 mi^2), Shanxi neighbors the provinces of Hebei, Henan, and Shaanxi, but is relatively isolated due to geographic features such as the Taihang Mountains and the Yellow River (Figure 3).

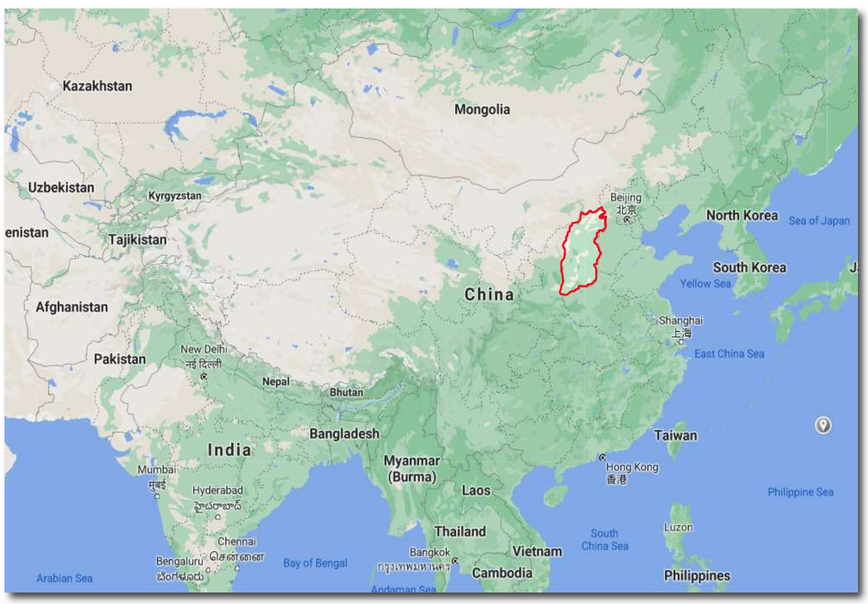

Figure 3- Map of China highlighting Shanxi Province (Google Maps, 2021).

Shanxi is a relatively rural province that remains one of the largest suppliers of coal in China. The geology of Shanxi explains why it is such a prominent supplier of coal. Two basins, the Qinshui and Ordos Basin characterize the region. As a result, Shanxi has major coalbeds including the late Carboniferous Taiyuan bed and the early Permian Shanxi bed (Figure 4).

The Qinshui basin and the eastern margin of the Ordos basin are the largest development areas in China, contributing more than 70% of total reserves with an estimated 300 billion tons of coal present. The coal grade is higher in this area due to magmatic episodes associated with the Yanshan mountain movement (Chen et al., 2019).

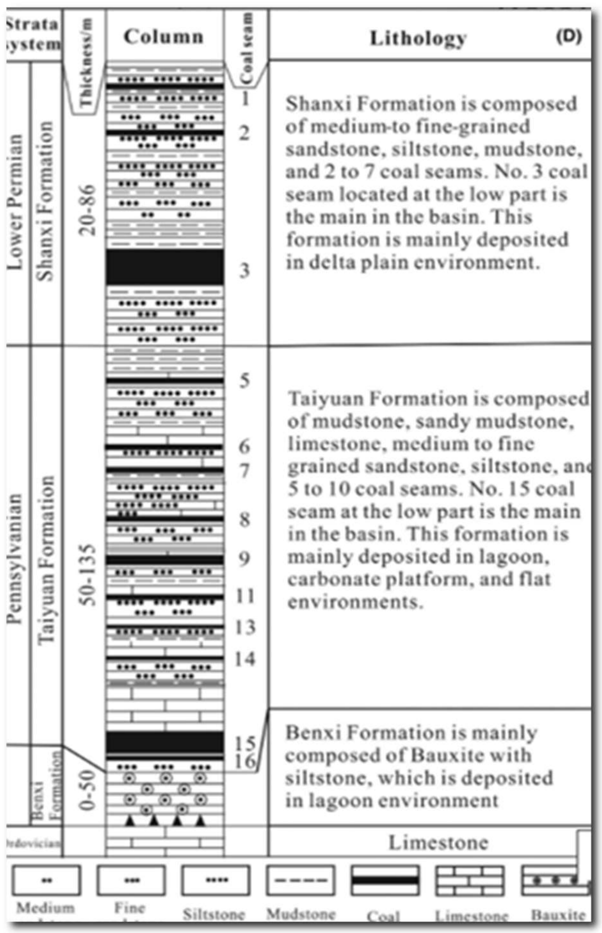

Figure 4 - Stratigraphic column of the Taiyuan and Shanxi formation in China (Chen et. al., 2019).

Central Appalachia as defined by the Appalachian Region Commission (2009), consists of areas in eastern Kentucky, southwest West Virginia, western Virginia, and northeastern Tennessee (Figure 5A). Because of the geology that characterizes this region, central Appalachia became the backbone of America's energy sector after the industrial revolution due to its abundance of coal. The coalbeds of this area are members of the Pottsville Group (Figure 5B) and include the Fire Clay zone of Kentucky and West Virginia; Pond Creek zone of Kentucky, West Virginia, and part of Virginia; and the Pocahontas No. 3 coalbed of West Virginia and Virginia (Figure 5C). Most of the formation and deposition of these coal deposits occurred within the middle to late Carboniferous much like the coal deposits in Shanxi. The coal in this area is predominately bituminous grade meaning that it would produce less energy compared to the anthracite variety mined in the Qinshui Basin.

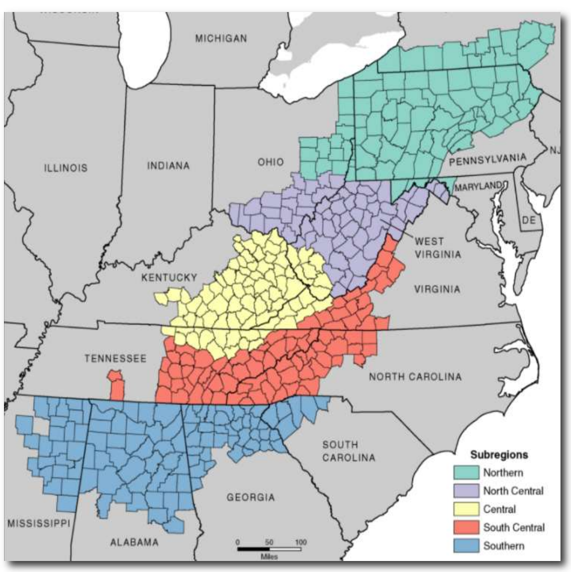

Figure 5A - Subregions of the Appalachian region in the United States (Appalachian Regional Commission, 2009).

SYSTEM	SERIES	GROUP	ASSESSED COAL BED or ZONE
PENNSYLVANIAN	UPPER	Monongahela Group	Pittsburgh coal bed
		Conemaugh Group	
	MIDDLE	Allegheny Group	Upper Freeport coal bed Lower Kittanning coal bed
	MIDDLE / LOWER	Pottsville Group	Fire Clay coal zone Pond Creek coal zone Pocahontas No. 3 coal bed

Figure 5B - Stratigraphic column of coal zones and beds in Appalachia (United States Geological Survey, 2002).

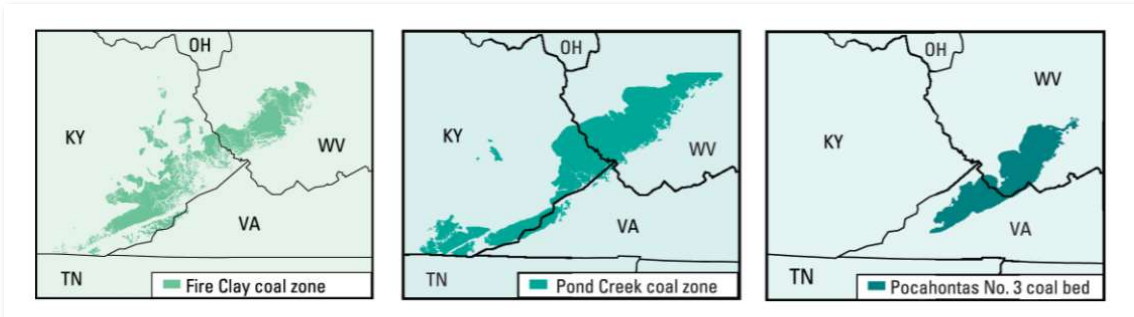

Figure 5C - From left to right: locations of the Fire Clay coal zone, Pond Creek coal zone, and Pocahontas No.3 coal bed in central Appalachia (United States Geological Survey, 2002).

Shanxi Renewable Energy

Even though a large amount of coal is excavated from Shanxi, many transitions have taken place to move away from coal and move instead towards renewable energy. In 2020, it was announced that one major Chinese coal company – Shanxi Coal International Energy Group – has turned its investments towards solar energy. The group is spearheading a solar panel project that will initially produce 3 gigawatts of energy but will eventually grow to produce 10 gigawatts of energy (Lewis, 2020).

The World Bank (2019) has also made a significant investment in renewable energy projects in Shanxi with a project titled *Shanxi Energy Transition and Green Growth Development Policy Operation.* The proposed objective of the project is to, "…Accelerate Shanxi's transition to a lower coal economy while diversifying economic growth and employment opportunities, thereby making significant contributions to global climate change mitigation and air quality improvement in Shanxi," (The World Bank, 2019, p. 2). Several target percentages regarding things like coal consumption and reduced carbon intensity per unit of gross domestic product (GDP) were gathered and have been compiled in the report. Phase one of the project was completed in 2020 and the second phase will coincide with the 14th five-year plan starting in 2021 (The World Bank, 2019).

Perhaps one of the best examples of China's renewable energy investment is seen at the county level in Ruicheng in Shanxi. In 2016, the Chinese government approved over a billion dollars USD (6.5 billion yuan) in investment money for the Ruicheng Solar PV Leading Technology Base and 1000 Megawatts (MW) of power are expected to be produced from the installed solar panels (Fu, 2019). Moreover, the solar installations are multifunctional as they were built high enough off the ground to allow flowers to be grown underneath them. The economic benefits of these projects are quite generous. It is estimated that about 183 million USD (1.2 billion yuan) will be added to Ruicheng's annual GDP and generate 23 million USD (150 million yuan) of revenue (Fu, 2019).

Poverty Alleviation in Central Appalachia

Some areas of Appalachia have seen economic improvement over the last few decades (Appalachian Regional Commission, 2021a). However, Central Appalachia has remained an economically distressed region despite serving as America's energy backbone. The Appalachian Regional Commission (2021a) calculates the economic status of counties within the region by examining the three-year average unemployment rate, per capita market income, and poverty rate and comparing these values to the national averages. Thus, economically distressed counties make up the worst 10% of counties. As of 2021, there are 78 economically distressed counties in Appalachia and many of them are found in Kentucky, West Virginia, and Virginia (Figure 6).

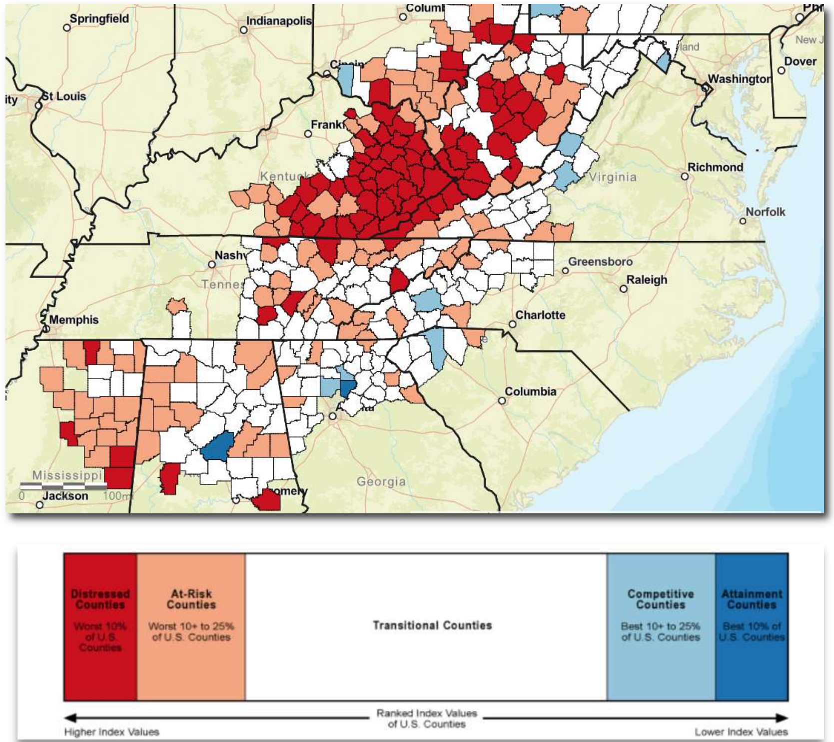

Figure 6 - Economic index values of counties in Appalachia (Appalachian Regional Commission, 2021b).

Efforts have been made to introduce small- and large-scale renewable energy projects to the region. The Kentucky Solar Energy Society (2020) demonstrates the applications that green technology can have in smaller towns. For instance, in Letcher County, Kentucky three projects are documented by the society which includes instillations at two non-profit organizations and one small business (Kentucky Solar Energy Society, 2020). The small business named Annie's Frugal Finery, notes that the seventy-six solar panels installed not only have a positive impact on the environment but will also save an estimated $175,000 over 25 years. The Hemphill Community Center saves over $300 monthly from the installation of 66 solar panels. A representative of the center stated, "…solar is the reason we are able to stay open right now" (Kentucky Solar Energy Society, 2020).

Beyond non-profits and small businesses - municipal centers, farms, residential areas, and faith-based organizations have also installed solar panels. The savings accumulated could directly or indirectly be funneled back into the community to support growth and economic revitalization, which was seen in China's SEPAP programs (Zhang, Wu and Qiu, 2020).

Environmental remediation and protection would also be an added benefit of using renewable energy in central Appalachia. As mentioned before, mountain top removal mining not only has negative health effects but also harmful environmental effects. Burial of streams by the removed sediment can severely damage ecosystems not only at the head of a stream but also downstream. Concentrations of the metals manganese and aluminum, as well as the metalloid selenium, can accumulate at such high levels that bioaccumulation can occur, causing defects in the organisms in that ecosystem. For instance, in some areas of mountain top removal mining, selenium has accumulated to four times the toxic level, causing deformities in larval fish (Palmer et. al., 2010). Any organism that consumes these fish would also experience adverse health effects. Thus, the ecosystem is disrupted, and sources of drinking water become contaminated.

DISCUSSION

There are various factors that could explain why China and its' provinces have had more success in implementing renewable technology while the United States and central Appalachia in comparison have not. One of these factors would be governmental differences. Ultimately, China is a communist state with an authoritarian government, meaning that anything the ruling party decides to accomplish will be accomplished with little opposition, so the centralization of China's government ultimately expedites the transition to renewable energy. The United States is a federal republic where representatives are elected to create laws, so the semantics of regulations and implementation regarding renewable energy could be stuck in federal and state legislation in the United States for years. Not all planning and regulating power would need to go to the federal government though. China's 5-year plans illustrate an optimal balance between federal and local governments. The 5-year plans outline achievable goals and create a certain degree of accountability within a 5-year period, but the provincial governments can decide how to best meet these goals.

From a technological standpoint, the timing of China's Mao-era industrialization and subsequent electrification efforts could easily play a role in China's transition to renewable energy. By the time China began pushing for electricity access across the country, renewable energy technology was more widely researched and available. Thus, instead of spending time and energy reworking an existing power grid, they could focus on just implementing renewable technology. On the other hand, the United States began electrification earlier; they had more time to build an energy economy based around nonrenewable energy. Because of the history that coal has in the United States, it has not simply served as an energy source, but it has fashioned a culture of its own by fostering a sense of “coal heritage”, thus making it easier to squelch the negative memories of the coal industry that have damaged the central Appalachian region (Lewin, 2017).

Another issue may lie in the availability of a particular technological resource – rare Earth elements (REEs). The United States was once in relative control of the trade of rare Earth elements. In the late 1940s, a deposit of bastnaesite was discovered near Mountain Pass, California. Bastnaesite is often found to contain the light rare Earth elements lanthanum, yttrium, and thorium, all of which have a wide variety of commercial and industrial uses today. For instance, yttrium is used in lasers that cut through metal, while thorium is starting to be used as an alternative to uranium in nuclear reactors (Royal Society of Chemistry, 2021). The mine in Mountain Pass is still in operation and today is owned by Molycorp Minerals and remains the most prominent REEs mining and processing facility in America.

However, as time progressed China became the leader in extraction of REEs. In fact, China houses about 35% of the world’s known reserves and in 2018 mined 70% of all rare Earth elements extracted that year (Clearworld, 2020). REEs are used extensively in renewable technology including producing solar panels, wind turbines, and electric cars.

The abundance of China’s REEs would explain why much more academic research pertaining to REEs has been conducted in China compared to elsewhere in the world. This academic interest was initially propelled by Professor Xu Guangxian who used his chemistry background to study the extraction of REEs from their ores and eventually launched several research programs related to REEs. His most important research developed the Theory of Concurrent Extraction which became a milestone for rare Earth separation particularly in solvent extraction (Chunhua et. al., 2006). Today, REEs are mined in various provinces across China from Sichuan to Inner Mongolia (Hurst, 2013).

China is also investing in REE mining operations outside of the country. They have paid particular interest to the Australian market, where they have a stake of up to 25% in Arufura Resources Ltd (Hurst, 2013). China even looked at the United States for potential reserves. In fact, they almost purchased Mountain Pass, however, the deal eventually fell through.

The United States has become dependent on China for REEs. However, China has been restricting its export quotas in recent years to focus more on internal industry. As their population continues to grow China anticipates greater domestic demand for products that utilize rare Earth elements. Moreover, the recent trade war between China and the United States has tensions rising, and China has threatened to drastically reduce the amount of REEs that they export to the United States which could further hamper the transition to renewable energy for the United States (Chang, 2019). However, this does present a possibility to strengthen overall U.S.-China relations by increasing trading which would be beneficial to both parties. Otherwise, the United States will have to look to other countries to access rare Earth elements.

Cultural differences between China and the United States could also explain the difference in transition between the two countries. China generally adheres to cultural collectivism while the United States values individual freedom and identity. Collective societies place a higher value on what happens to a group rather than individuals, thus group members are entitled to know and regulate the individual's actions. On the other hand, individualist societies see the individual taking responsibility for their own actions and therefore the individual strives to fulfill their own needs and interests. Both collectivism and individualism can impact a society's cultural values and norms, political influence, family relationships, and social relationships (Chung and Mallery, 2000).

So, China's collectivist ideology could be part of the reason that Shanxi, while possessing large coal reserves, has still made a larger effort to transition to renewable energy. However, to benefit the individual consumer, the United States will likely need to institute a stronger capital incentive. As China has illustrated, feed-in tariffs can be effective economic incentives, but they tend to decline in effectiveness in the long-term if no adjustments are made to fluctuating market prices (Oxford Institute for Energy Studies, 2020). The Incentive Tax Credit implemented by the United States could be a more beneficial incentive alternative compared to FITs. The tax credits are not only simpler in their implementation because they do not have to be constantly adjusted with changing market prices, but when combined with a tactic like a set net metering price, they could potentially serve as a relatively uncomplicated financial incentive for renewable energy in the United States (Center for Sustainable Systems, 2020). However, Congress has yet to renew the Incentive Tax Credits after the year 2024, which could present an issue.

A capital incentive is not only beneficial but also necessary in economically distressed regions like central Appalachia to help promote renewable energy installation. The largest costs associated with renewable energy are upfront costs. For example, installing a residential set of solar panels could cost anywhere in the range of 15,000 to 25,000 USD (Energy Sage, 2021). This cost could be too overwhelming for smaller entities like churches and businesses. Thus, the federal government could consider increasing the Incentive Tax Credit for these areas.

CONCLUSION

While China possesses vast reserves of coal, it has been leading the global effort to transition to renewable energy. Because of this effort, rural regions have access to a sustainable form of energy and a method to help alleviate poverty.

One of the most economically distressed regions in the United States consisting of Eastern Kentucky, West Virginia, western Virginia, and northeastern Tennessee could benefit tremendously from implementing renewable energy technology on both a small-scale and large-scale as evidenced by China's efforts.

Shanxi, China is an example of what central Appalachia could attain. Ultimately to obtain this reality, the United States and central Appalachia will have to adopt new mindsets and policies to promote the growth of renewable energy. A centralized plan that holds states accountable would be the first major step needed to bolster renewable energy transition. However, due to the wide range of climates and resources across the country and even within central Appalachia, states could decide how to best meet these central goals.

If central Appalachia transitioned to renewable energy technology, then the region could potentially see economic and environmental benefits. Rural areas in China were consistently able to increase their GDPs after solar instillations were made, and places like Ruicheng in Shanxi show how renewable energy can even be multifunctional. Mountain top removal mining areas could be repurposed and prevent further damage to the environment and human health. And if a coal-rich province is China can accomplish this transition, then so can central Appalachia.

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