Economic, Environmental, and Regulatory Feasibility of Rare Earth Element Mining in the Powder River Basin

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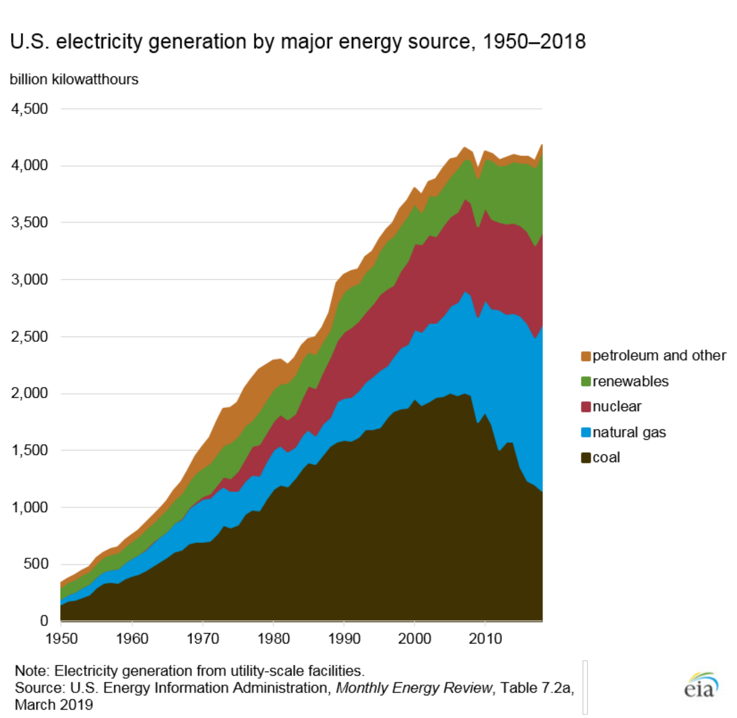
Introduction

Wyoming has long been known for its coal deposits and coal-fired electricity generations. However, with many energy outlooks predicting long term decline in coal markets, places such as Campbell County situated in the Powder River Basin (the area with the most coal production in Wyoming) may need to diversify local economies in order to maintain local job markets and financial welfare. One proposed new industry lies in rare earth mineral mining. The category of rare earth minerals consist of the Lanthanide series as well as often Scandium and Yttrium (sometimes referred to as REYs with these two additions). There is an increased demand for REE's because of current trade wars with China (who holds nearly total market power in rare earth production). Three different production models (see Table 1 below) were considered and a cost benefit analysis was performed upon all scenarios. Different variables were manipulated to test sensitivities within the BCA ratios.



	SCENARIO 1	SCENARIO 2	SCENARIO 3
PRODUCTION MODEL	*Dual Production –* New production of REY materials from raw coal while continuing with current coal production for energy usage	*New Primary Production –* Production of REY materials from raw coal in a new production facility	*New Secondary Production –* Production of REY materials from fly ash and coal byproducts.
FUEL COAL PRODUCTION?	Yes	No	Yes

Table 1 – BCA Scenarios

Regulations

The safety of mine workers in the United States is regulated by the Mining Safety and Health Administration (MSHA). While rare earths are listed under MSHA's mining industries and they hold the regulatory power over the human health standards of the proposed mines, there could be safety hazards which are not as well-known as other more common industries such as coal mining (MSHA, 2019). Environmental safety regulations are under the power of the Environmental Protection Agency. The EPA has already made precautionary steps towards effective regulations and has established the Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) program which places regulations about the waste produced in the rare earth production and waste cycles (EPA, 2018). However, this focuses on the material post-processing and may still leave gaps for environmental protection during mining and production phases. Additionally, processing coal ash could prove difficult from a regulatory perspective. Coal ash is a highly regulated material. There are regulations about what constitutes an appropriate secondary use for the product. This could cause issues when beginning to implement a program such as Scenario 3 (secondary production). All of these regulations can extend the time to start up and be costly to follow.

Coal Market Trends

While energy markets can be unstable, some general trends can be observed in the mining industry employment in the last several years. Though there was a fairly steady growth until around 2010, the years since have shown a small, but clear, downward trend in the overall number of mining employees (see Figure 3 at right). The production averages show a similar trend, although less predictable. There is a clear decline since the peak which occurred near 2011. There are a few reasons for these changes including mine closures, contract changes, regulation changes, and changing technology. However, the severe dip in production does not appear to be recovering, and according to many energy projections, will continue to fall into disuse.

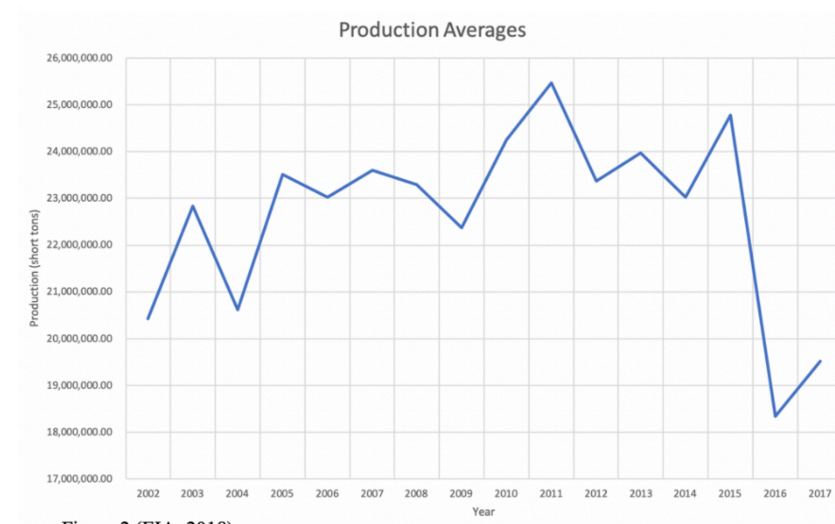


Figure 2 (EIA, 2018)

Cost Benefit Analysis

For this particular situation, it is important to note that the development of the rare earth mine would likely need to be at least not in conflict with, if not in cooperation with, existing coal mines due to community reliance and geographic proximity as well as the possibility of dual or secondary production. So the distribution of resources between coal and rare earths needs to be considered. Looking at Figure 4 at right helps illustrate the possible efficiency of the separate proposed scenarios for implementing a mine. While it may not be possible to precisely pick the success of each scenario, they can be estimated. For example, producing just coal or just rare earths is an efficient use of capital and labor, leading to a place on the PPF above. However, the secondary production and dual production models cannot be as easily placed, but a guess may be ventured. In Scenario 3 (secondary production), the full amount of coal can be produced with the full amount of rare earth also being produced, leading to an outward shift in the PPF. In Scenario 2 (dual production), it is difficult to predict exactly where the scenario will go. The implementation of the rare earth production will likely lead to a decline in production of coal. However, it is unclear if this will be efficient and be on the PPF, be lacking efficiency or be above the current PPF. The benefit-cost analysis gives better insight into how the different scenarios will perform. In the BCA, certain variables were manipulated (human health costs, salary, number of employees, discount rate, and environmental costs), and shows through the BCA ratios which components are more able to flex and which could cause more drastic changes to costs or revenues. The BCA had to be established on a variety of assumptions and estimations due to availability of information. The sensitivity analysis also allows insight into which estimates may need to be investigated more thoroughly to produce a more accurate investment risk estimation. The overall BCA ratios were all between 1.5 and 1.8. This is a positive finding and indicates that all situations in the table above would be cost effective investments. However, this is still a rather low BCA ratio so it may not be as enticing to a traditional investor. However, if the government were to subsidize a portion of the project this ratio could significantly increase. From my findings, single-stream raw coal production has the highest BCA ratio followed by the secondary production of rare earth from ash. One factor which could alter these results would be a better estimation of environmental costs which would likely not be possible until a specific mine site was chosen but could potentially lower the BCA of the single-stream scenario.

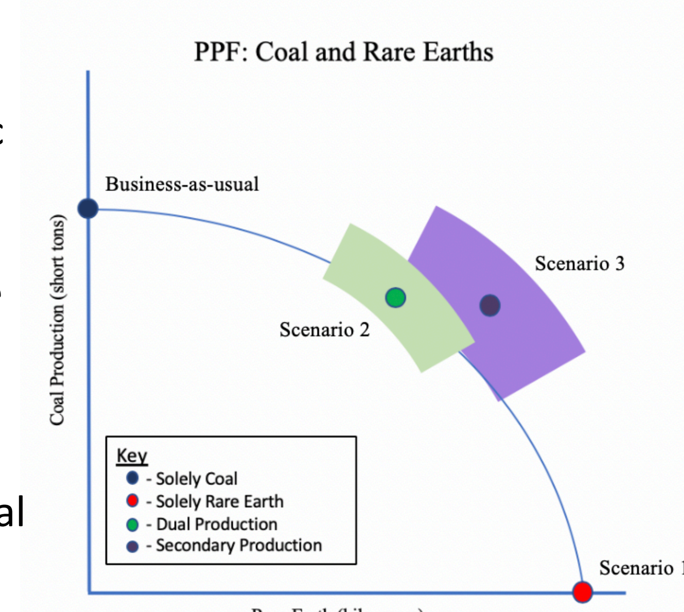


Figure 5

Sensitivities in the BCA Ratios

Human Health	$1/ton coal $1/kg of REE	$.05/ton coal $.05/kg of REE	$.05/ton coal $.05/kg of REE	$.05/ton coal $.05/kg of REE	$.05/ton coal $.05/kg of REE
Salary	89,311	65,000	89,311	89,311	89,311
Employees	300	300	400	300	300
Discount Rate	5%	5%	5%	8%	5%
Environmental Costs	Coal	Coal	Coal	Coal	½ Coal
Scenario 1 *(BCA Ratio)*	*1.6019*	*1.6022*	*1.6017*	*1.5669*	*1.6438*
Scenario 2 *(BCA Ratio)*	*1.7755*	*1.7758*	*1.7753*	*1.736*	*1.8245*
Scenario 3 *(BCA Ratio)*	*1.6865*	*1.6869*	*1.6864*	*1.6497*	*1.7307*

Table 2

Conclusions

The BCA resulted in ratios above 1 in all three scenarios. As the variables were manipulated to test sensitivities, the BCA ratios all remained between 1.5 and 1.8, indicating a cost effective investment, although still a fairly low ratio. The discount rate was the variable which had the most drastic impact when manipulated. Scenario 2 (single-stream production) consistently had the highest ratio followed by Scenario 3 (secondary ash production). Scenario 1 (dual production) consistently had the lowest BCA ratios. From the initial gathering of data, the pursual of a single stream rare earth facility from raw coal seems the most profitable. However, to supplement the coal industry and to accommodate an easier energy transition and maintain current labor forces, adding a secondary production to an existing coal mine may be the best from the perspective of profitability, environmental benefits (repurposing an environmental hazard, which there is an abundance of), and local economy.

Sc. 1
- Consistently lowest ratio

Sc. 2
- Consistently highest
- Potential high environmental costs

Sc. 3
- Second best BCA ratio
- Positive environment/community

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