IdealRatings®

White Paper

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COAL: A SUSTAINABLE INDUSTRY?

ABSRACT

With a debate between whether coal industry will sustain its stance in the global energy market, ranking third with a 27% share, or will it fade away given the rising movements towards decarbonization, it was thus deemed important to tackle the details of this business. Climate change and human rights topics are making their way to news headlines, more frequently lately, and their relevance to the coal industry couldn't be ignore. Given the industry's nature and with the current trends towards environmental conservation and human rights awareness campaigns, coal industry is facing various challenges which will definitely affect involved companies' financial status. Throughout this white paper, IdealRatings, Inc. will go in depth in the coal industry; from basic definitions, to formation & mining processes, types and global geographical presence. Potential ESG and financial risks will also be highlighted. Renewable energy still seems to be the normal possible alternative, though a clear plan has to be set by companies towards gradual shifting in its business model and plans.

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"It is quite unlikely to imagine the end of coal generation given the global reserves available and the affordable energy it provides."

Coal Industry at a Glance

Description

''Coal is a fossil fuel and is the altered remains of prehistoric vegetation that originally accumulated in swamps and peat bogs''. It is a sedimentary and organic rock composed of carbon, hydrogen, oxygen and nitrogen. Coal uses vary from one country to another; though mostly it's used for electricity generation, steam generation, and heat production. It is also used as an input in other industries; i.e. steel, cement and silicone.

Geographical Breakdown & Market Leaders

China

India

U.S.

Shenhua Group

China Coal Energy Group

Datong Coal

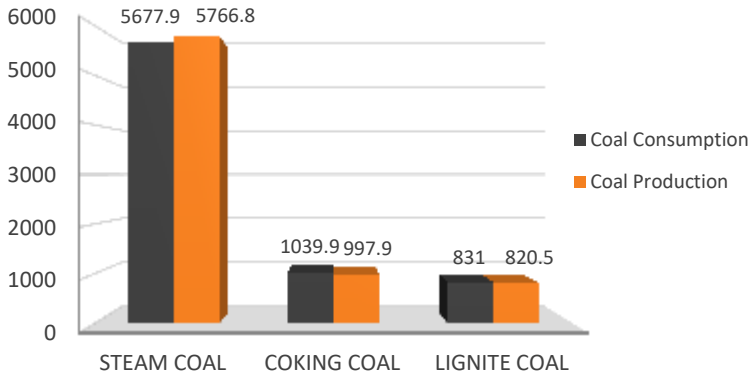
Coal India

Peabody Energy

Arch Coal Inc

Cloud Peak Energy

Breakdown of Total World Coal Production & Consumption by Type



Source: International Energy Agency

"Global Coal consumption witnessed a rebound of 0.9% after three years decline."

Industry KPIs

45%

45%

10%

Coal Industry Overview

Definition, formation & mining process

As defined by the World Coal Organization ''Coal is a fossil fuel and is the altered remains of prehistoric vegetation that originally accumulated in swamps and peat bogs''. It is a sedimentary and organic rock composed of carbon, hydrogen, oxygen and nitrogen. Coal uses vary from one country to another; though mostly it's used for electricity generation, steam generation, and heat production. It is also used as an input in other industries; i.e. steel, cement and silicone.[1]

The first coal formation can be traced back to, around, 360 million years, when accumulated silt and other sediments together with the earth's crust's movement has buried swamps and vegetation into greater depths where extremely high temperature and pressures exist. Consequently, chemical and physical changes occurred in the buried substances leading to its transformation into peat. Exposed to further temperatures and pressures, peat gets transformed into coal through a process known as "Coalification". Starting with the lowest grade of coal Lignite, then Sub-Bituminous, then Bituminous, and then the highest grade of coal Anthracite.[2]

Extraction of coal involves one of two methods; 'Surface Mining" or "Underground Mining". Choosing between the two methods entails several technical and economic factors such as; thickness, depth and quality of coal deposit, strength of the material above and below the coal deposit such as rocks, requirements of the coal purchaser, geological conditions of the region where the coal deposit is situated, ground water conditions, capital investment. [3] In certain situations, coal deposits can be mined using surface methods first then underground extraction is applied. The below table summarizes key aspects of the two mining processes[4]:

	Surface Mining	Underground Mining
Reason of usage	Adopted when the coal deposit is near the surface.	Adopted when coal deposits are buried too far underground that it can't be extracted using surface mining.
Methods	• ***Area mining:*** applied on broad area of flat land. • ***Contour mining:*** Used when coal deposits are on certain heights such as steep, hilly or mountainous areas. It allows the partial removal of the coal at mountains. Drills and explosives are used to remove the rocks over the coal deposit. • ***Auger mining:*** The cheapest form of surface mining. In this process, large diameter holes are drilled up to 200 feet using augers to access coal deposits.	• ***Room-and-pillar***: Several entries are developed into the coal deposit and connected by wider entries called ''rooms''. Those rooms are cut through the coal deposit at the right angles of the entries forming by those thick pillars of coal. • ***Longwall mining:*** huge mining machines are used, and large blocks of coal reaching up to 4 km are extracted

Types: Characteristics & uses

Coal can be categorized according to type, rank and grade. The former refers to the geological classification of the coal based on its general appearance. Some coal has an internal layering called banding, which differ in their brightness and dullness. As for the 'Rank' it refers to the degree of coalification or the degree of coal maturity, whereas 'Grade' refers to the classification based on the purpose of its usage.[5]

Type

Humic: banded, dark brown or black, developed from wood or reed.

Sarpropelic: non-banded, matte black, and grows in non-woody sources such as spores, algae and others

Grade

Steam / Thermal

Metallurgical / Coking

Chemical & Specialty

Rank

Lignite

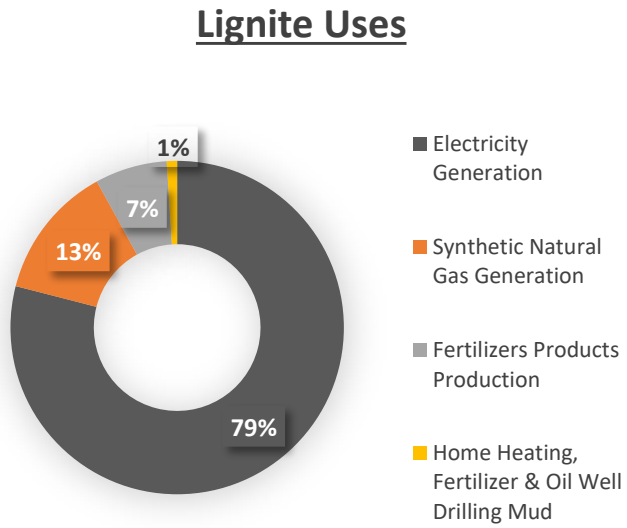
Sub-Bituminous

Bituminous

Anthracite

Coal ranks are the most commonly used by companies in the market.

- **Lignite / Brown Coal**: This type of coal is known by its clear brown color, softness, and high moisture content. Moisture content is an important parameter needed in determining the calorific or heating value of the coal. Lignite has lower carbon content resulting in low heating value, which doesn't make it burn easily as other coal grades, and more carbon dioxide emissions. Compared to the other types of coal, lignite has greater sulfur and mercury compounds.[6]
  Despite its damaging environmental effects, this coal grade is heavily used in various countries as shown in the following graph.[7]



Source: Lignite Energy Council

- **Sub-Bituminous / Black Lignite**: A grey-black or sometimes dark brown rock that is made of almost pure carbon. It is a transitional stage

between low quality lignite and higher quality bituminous. Compared to lignite, this type of coal has higher carbon content and lower moisture content.[8]

- **Bituminous / Black Coal**: Shiny and generally hard coal. Its high carbon ranging from 76-90 and low moisture content makes it the ideal type of coal for steel and cement production.[9] Bituminous coal has two main subtypes:
  - Metallurgical / Coking Coal: This type is mainly used in steel and iron production. Through the exposure to extremely high temperature reaching 1000-1100°C and in the absence of oxygen, all volatile components of the coking coal are evaporated, and coal is transformed into a high carbon material called ''coke''.[10] The coking process starts by pulverizing or ''crushing' the coking coal and then preheating it at a temperature ranging from 150-250˚C. Coal is then transferred to coking chambers and exposed to extreme heat coming from combustion. The coal is kept in the coking oven for about 17 hours at a degree of 1100˚C. After the coking process coke is pushed to what is called '' quenching car''. This quenching car transports the produced coke from the oven to a quench tower where the coke is cooled to a certain temperature.[11]
  - Thermal / Steam Coal: This type is mainly used in electricity generation and cement making. About 40% of electricity is generated using thermal coal. The process of electricity generation starts by pulverizing the thermal coal to a powder that can be easily burned later. Extreme heat to water is applied using a device called "boiler". Resulting steam spins a turbine connected to an electricity generator. The spinning turbine causes large magnets to turn within copper wire coils which are found inside the generator. Those magnets cause the electrons in the wires to move creating an electrical current and generating electricity. A transformer is used to control the increase or decrease of electricity voltage.[12]
- **Anthracite:** A hard & black grade of coal made of almost pure carbon reaching about 95% and very low moisture of approximately 5%. It is the highest rank of coal and one of the cleanest types, burning for longer times and producing less smoke than other types. When burned, Anthracite produce extremely hot flame which makes it the ideal grade of coal used in heating systems in houses and commercial building.[13] Anthracite is considered economical from a cost point of view, even when compared to other fuel sources such as wood, gas, kerosene and fuel oil.

The following table summarizes the different properties of coal ranks[14]:

Rank	Low Rank		High Rank	
	Lignite	Sub-Bituminous	Bituminous	Anthracite
Age:	----------Increase---------->			
% Carbon:	65-72	72-76	76-90	90-95
% Hydrogen:	~5----------decreases---------- ~2			
% Nitrogen:	< ---------- ~1-2 ---------->			
% Oxygen:	~30----------decreases---------- ~1			
% Sulphur:	~0----------increase---------- ~4 ---------- decreases---------- ~0			
% Water:	70-30	30-10	10-5	~5
Heating value (BTU/lb.)	~ 7000	~ 10,000	12000-15000	~15000

Geographical Breakdown & Market Leaders

China, India and USA, respectively, dominate the first three ranks in terms of global coal production and consumption.

Coal Production & Market Leaders

China is the world largest coal producer with an amount reaching 3,349,000 tons, in 2017, followed by India with a total amount of 717,000,000 tons and then the US with an amount of 701,000,000 tons. 2017 witnessed an increase in coal production reaching 7,549 Mt showing 3.1% increase after almost three years of decline, though not yet reaching the 2013's peak production; 7,975Mt.[15]

Such increase is mainly buoyed by the 3.3% surge in China's coal production.[15] According to China's National Coal Association; the country is currently capable of producing more than 100 million tons of coal per year with only six mining companies. The biggest coal miners in China are Shenhua Group, China Coal Energy Group and Datong Coal Mine Group. Based on the country's National Development & Reform Commission (NDRC), a pertinent plan has been set to be reached by the end of 2020 in which China will depend on creating mega-miners with a capacity of 100 million tons each per year. This will be done through mergers and eliminating around 800 million tons of outdated capacity and add around 500 million tons of advanced capacity to reach a total output of 3.9 billion tons a year.[16]

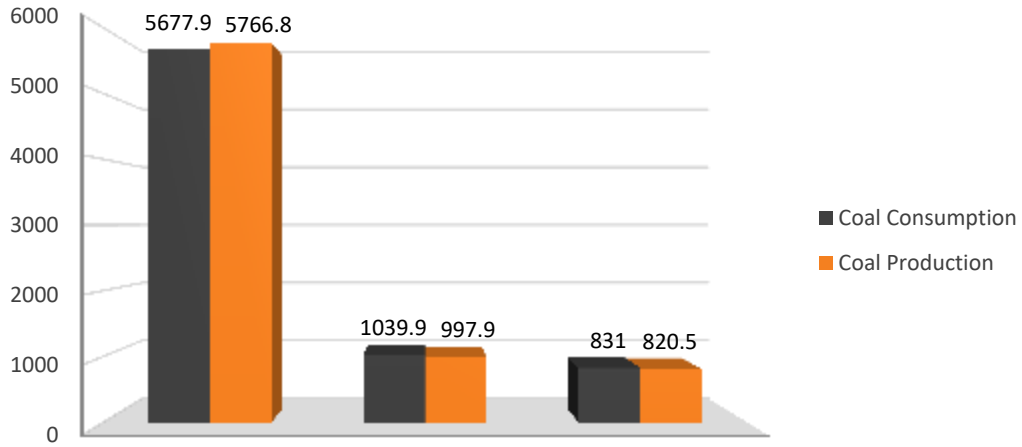
As for coal production in India, it mainly comes from the public sector that contributes by around 95% to the national production.[17] Coal India Limited (CIL) is considered the single largest coal producing company worldwide; fully owning eight subsidiary companies in India alone; Eastern Coalfields, Bharat Coking Coal Limited, Central Coalfields Limited, Western Coalfields Limited, South-Eastern Coalfields Limited, Northern Coalfields Limited, Mahanadi Coalfields Limited, and Central Mine Planning & Design Institute Limited (CMPDIL).[18]

The US comes as the third largest coal producer through its main coal companies; Peabody Energy Corp, Arch Coal Inc., Cloud Peak Energy, Murray Energy Corp, Alliance Resource Partners LP, and others. The listed 23 companies stated by the U.S. Energy Information Administration as major U.S. coal producers controlled 88.1% of the country's total coal production. [19]

Steam coal dominates 75.2% of the coal production, followed by Coking coal with 13.78% share in the market, and finally Lignite with 11%, as highlighted in the figure below. OECD accounts for 16.4% from total steam production, showing a major decline from its 1978 share; 42.8%. This is mainly supported by the relevant climate change regulations taking place in this region and the current exits from coal industry. On the other hand, coking coal showed a flat increase compared to last year, whereas lignite increased by 1.3% supported by a slight 0.2% increase in the OECD's production and 5.5% increase in Turkey's production, which comes in third in global lignite production. [15]

It should be noted that in Western Europe, there are accelerating coal exit strategies with expectancies that by 2023 both France and Sweden will have closed their last coal power plant. Whereas in Eastern Europe, demand still remains unchanging and even countries such as Balkans, Greece and Poland are having new coal power plants under construction.[20]

Breakdown of Total World Coal Production & Consumption by Type



Source: International Energy Agency

Coal Consumption

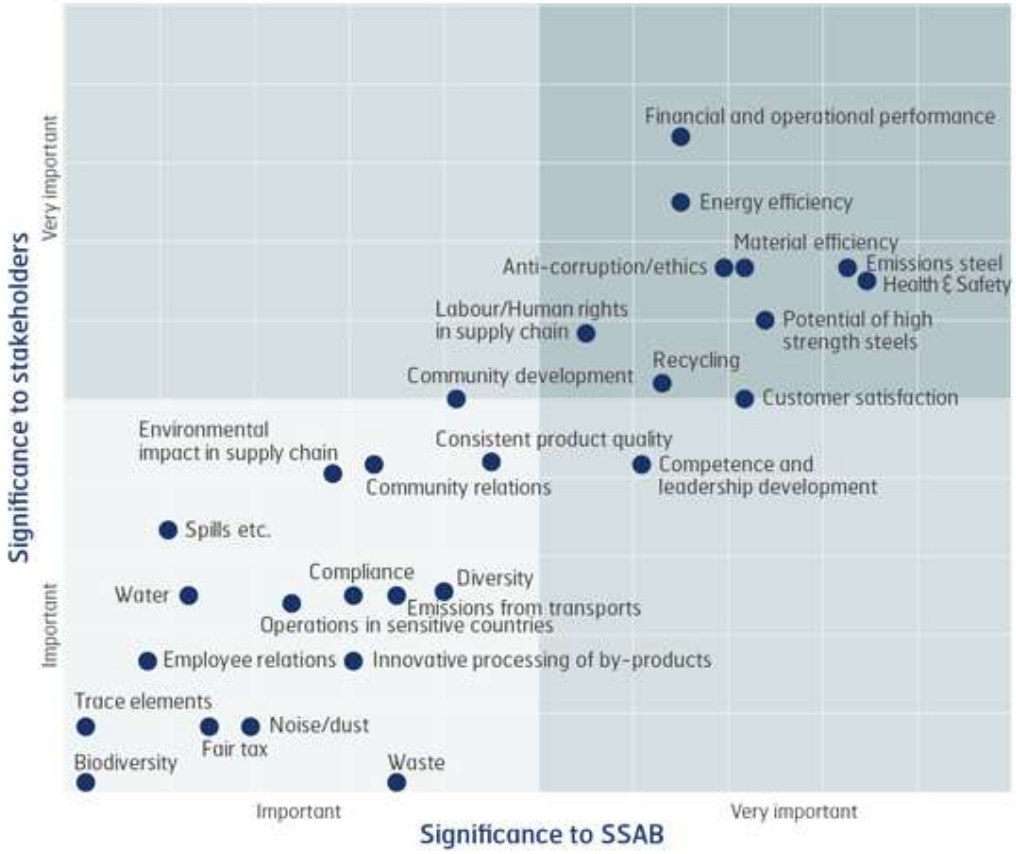
Global Coal consumption witnessed a rebound of 0.9%, after the three years decline. China controls more than half the world's coal demand, with total amount of 3,607,000,000 tons, followed by India which took USA's second rank since 2015, by 953,000,000 tons, and USA came in third with 649,000,00 tons.[15] After an absence in coal increments since 2013, in attempt towards reaching its decarbonization goal by 2030, China came back in 2017 with a trivial 0.4% increase.[16] With natural gas shortage and a 40% drop in hydropower productivity, China slightly increased its coal demand.[21] It should also be noted that China relies heavily on coal given its huge presence in relevant industries such as oven coke, crude steel and iron, controlling 66.9%, 49.6% and 60%, respectively, of global production.[15] On the other hand, USA witnessed a decrease for the fourth year in coal demand reaching the lowest value since 1978. This is supported by the country's plan towards increasing alternatives' usage such as solar and wind. Several coal units were closed and the remaining ones work for less hours and lower productivity rates.[22] This decrease was offset by an increase in India which continued its demand growth in addition to the previously mentioned increase in China.[15]

Similar to the production figures, steam coal takes the lead in global coal demand with 76%. It witnessed an increase of 1.4%, whereas coking coal came in second with 13%, showing an 0.7% decrease in global consumption. Lignite also showed an 0.9% decrease due to the OECD countries' greatest decline since 1978.[15]

Coal Industry Risk Profiling

ESG Analysis

In its risk assessment for coal industry, IdealRatings, Inc. has set the relative importance of Environmental, social, and governance pillar as 45%, 45% and 10% respectively. Several underlying KPIs do affect these pillars. The following section will, however, focus on the most important of these KPIs.



Environmental Impact

Coal's lifecycle; mining, processing, transporting, and burning, entails several procedures that have massive negative impacts on various environmental aspects. Being both water-intensive and energy-intensive, the industry affects key ecological pillars that includes water, air, and biodiversity. A heavy environmental responsibility is set on coal industry players with several pertinent global studies and initiatives taking place such as Paris Climate Agreement[1]. Also, the UN expectations that by 2025 1.8 billion people will be living in countries or regions with absolute water scarcity and two-thirds of the world's population could be living under water stressed conditions."[23] In case of irrational resources' usage and

45%

[1] 2030 agenda aiming at curtailing global average temperature increase by 2 degrees Celsius to avoid environmental catastrophes.

improper wastes management procedures, the below highlights a sample of possible environmental damages that could take place.

As previously highlighted, mining could take place in various forms with each having its possible hazards. Underground mining causes huge methane emissions leading to the risk of climate change.[24] Another form of coal mining; Mountain Top Removal[2], where air particulars and possible water contamination could occur in case of not managing wastes properly, that is in addition to biodiversity destruction due to vegetation removal. According to the Union of Concerned Scientists, almost 2000 miles of headwater streams have been buried and many more have been polluted, due to this practice.[25] Moreover, coal mining process in general could lead to Acid Mine Drainage; one of the main water pollutants resulting from chemical reaction between water and rocks in sulfur bearing minerals such as pyrite. [26]

After the mining stage, processing phase starts where coal is prepared before being transported and used in power plants. Coal is washed with water to remove impurities before the burning process. Resulting coal slurry is often stored in underlined ponds causing possible leakage hazards and thus more water contamination.[25] Coal is then either transported to the dedicated power plant or power plants are built near the mines.[27] In both cases toxic emissions gets released by transportation vehicles or during the building process of the plant.

Once in the coal plants, coal runs through a process to generate electricity. One of these processes is 'pulverizing coal'; crushing coal, burning it, running steam through a turbine to generate electricity. The other option is 'integrated gasification combined cycle' where coal is converted into gas that runs through a combustion turbine to generate electricity. Both methods emit carbon dioxide, sulfur dioxide, nitrogen oxides, particular matter, mercury and hydrocarbons.[25] The former method also entails high usage of water which definitely affects the quantity of the resource due to the cooling process, that is in addition to the waste water that could occur from the discharged resource that is not treated and reused.[26] Residues of coal combustion are known as 'coal ash' which also contains high amounts of toxic chemicals including mercury. Proper waste management entails reuse of this coal ash and other wastes products, it is, however, noted that some of them are stored in landfills, or uninhibited mines of ponds again causing a possible hazard of water infection.[25] As for the air pollution, negative climate change effects could take place in in various forms such as acid rain derived from nitrous oxides and Sulphur dioxide releases which causes solid contamination. Marine life is in danger during both mining and combustions processes.[23]

Social Impact

It is needless to say with the above-mentioned environmental hazards that human lives are in great risk of health problems. Both mine workers and people living in surrounding areas are exposed to the poisonous emissions and prone to drinking contaminated water which could lead to morbidity and mortality, though mine workers record even higher rates of such risks.

Aside from the vigorous nature of the industry requiring huge physical strength, workers operate in tough conditions with high temperate and humidity, dust, and absence of fresh air and natural light. As a result of their

45%

[2] One of the coal mining forms where entire mountains are flattened to unearth thin coal seams that are not reachable using regular underground methods.

regular exposure to coal dust, workers develop severe respiratory and lung diseases, such as Pneumoconiosis and are highly exposed to lung cancer.[28] Health diseases aren't the only challenge for coal miners, as accidents and injuries rates are significantly high during this process. Common accidents occur from various incidents such as; rock falls, mining equipment accidents, explosions, wet or muddy surfaces, very loud noise and electrocution[3].[29] Consequently, workers' absenteeism rates increase lowering by that the productivity rate, increasing the mining cost, and affecting the whole mining operation.[30]

Aside from the health and safety aspect, working conditions in the industry are quite threatening with various human rights breaches occurring such as child labor[31], forced labor, violations of workers' rights to collective bargaining.[32]

Governance Impact

"Natural resources are too often vulnerable to corruption", that's how Chair of Transparency International – Delia Ferreira Rubio – described mining process' risks. Given the socio-economic and environmental effects natural resources' mining, it is expected that corruption risks could arise easily. Among such risks is rent seeking and bribes during mining approvals. Reasons of these occurrences vary; from inadequate social and environmental assessments and due diligence on license applicants, to poor political transparency and unclear decision-making criteria.[33] Given the long life-cycle of mining, transparent and adequate compliance management procedures should be intact to guarantee proper risks and crisis management. Moreover, to ensure open access to coal, as a non-renewable resource, having in line anti-competition policies should be a must. This is to avoid price manipulation and price fixing risks that occur usually during the winter peak season.

10%

Financial Risks

With responsible investment assets under management on rise, reaching $22.89 trillion in 2016 and dominating almost 26% of professionally managed assets globally[34] and with the above detailed ESG risks it is clear that involved companies are in tough financial position. Companies are recommended to abide by stringent regulations so as to cope with the market updates. All these rules come at an initial cost on corporations during its first implementation which might affect their profitability, though temporarily given the long term benefits it has.

From an environmental aspect, regulatory challenges arise especially with the several related global movements. Accordingly, companies are required to upgrade their mechanisms throughout the coal's lifecycle to ensure proper environmental management, abidance by new rules issued frequently, lately, and to avoid costs of remedial actions. Socially, companies should work on having strong procurement policies to avoid possible human rights violations. Such policies are required to be assessed whether internally, or externally or both to ensure proper application. These assessments again come with

[3] A serious injury or death caused by electric shock

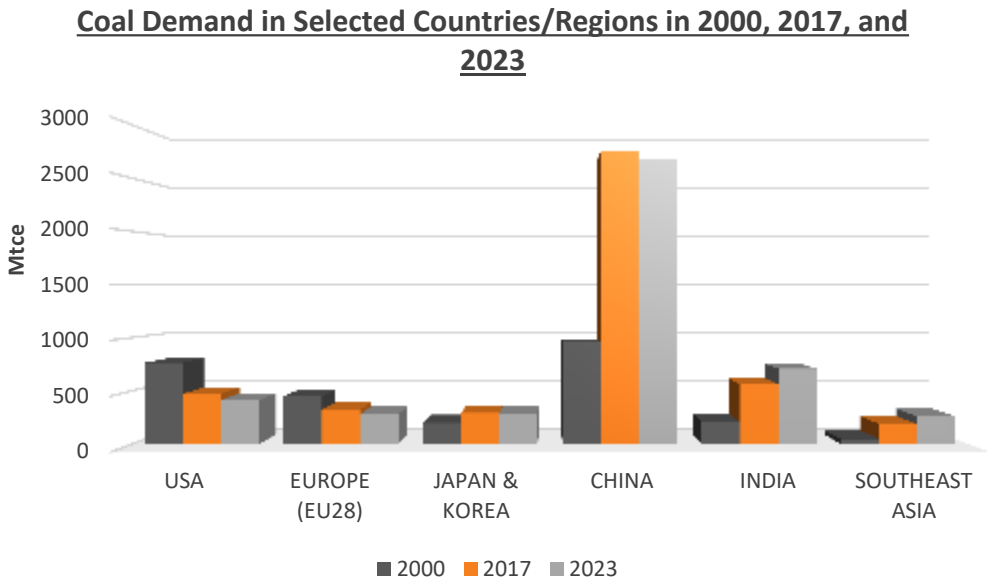
regular costs. Though weighing its benefit against possible losses in case of the occurrence of negative incidents, having these policies and their related assessments in advance will definitely be found rewarding.

Another possible risk is the competition faced from other alternatives; natural gas and renewable energy. The former's lower prices and higher efficiency is affecting the demand on coal. Renewable energy comes at even a lower operating cost than both coal and natural gas make itself more competitive, with expectancies that such cost could decrease by 20% from 2010 till 2020 due to experience curve effects.[35] Renewable energy saw 17% growth rate from 2016 to 2017 showing its largest increment on record. Wind energy is dominating more than half the market followed by solar energy with 21% of the total.[36]

Based on the above risks, several divestments from coal operations are taking place. Trying to cut its ties from this hazardous market and to match the updated stakeholders' responsible investment interests, several financial institutions have cut its investments to new coal mines.

Concluding Remarks

Despite the many challenges faced by this industry, coal's share in the global energy mix is expected to reach 25% by 2023; showing trivial 2% decrease. Declines in USA and Europe due to increased adherence to climate change policies will be offset by a stable production in China - which is trying to balance between its global position, market demand, and its decarbonization plan – and increased production from India and Southeast Asia.[20]



Source: International Energy Agency

Few recommendations are proposed to ensure sustainability of this market both financial and non-financially;

Setting global norms strictly confined to the coal industry

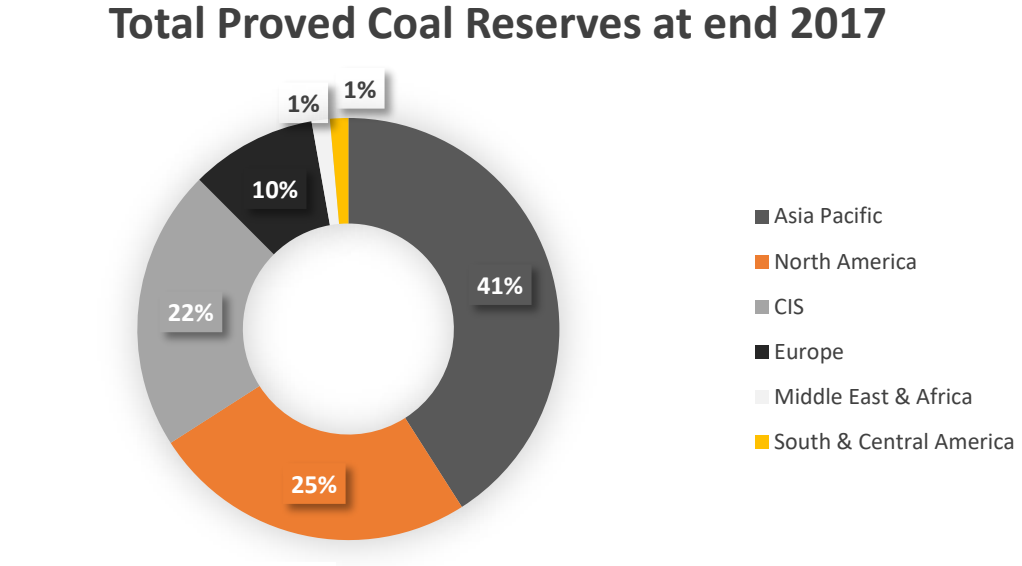
Obligatory international norms are suggested to be applied on all coal related companies. Before adding any pertinent company in its portfolio, investment firms are to be required to screen companies against such standards. These rules should entail environmental, safety & health, and governance guidelines. The following is a list of suggestions that could be used as a base for the international coal related norms:

- Companies in the coal industry should have a clear set plan regarding application of new technologies, and these plans should be set in a time frame not more than 3 years. Thanks to the efforts of Research & Development newer technologies are available regularly. Among these technologies is the 'Carbon Capture, Utilization and Storage' CCUS; where "Cos is removed from flue gas and from the atmosphere, followed by recycling the CO2 for utilization and determining safe and permanent storage options".[37]
- Tax exemptions or incentives to be done for companies applying new environmental technologies.
- In terms of safety & health, regular x-rays could be done to check for any diseases at early stages, 'task rotation'[38] could be implemented to decrease injury rates.
- Unified licensing process to be implemented worldwide.

To ensure abidance by such norms, third party companies should be assigned, by the international organization that has set the norms, to audit the company's regularly. Audit results should be publicly announced on the organizations website.

Taking the best of both worlds

It is quite unlikely to imagine the end of coal generation given the global reserves available and the affordable energy it provides. Moreover, renewable energy recorded its largest increment of 17% growth rate by end of 2017.[36]



Source: British Petroleum

An optimum solution would be using coal that implements environmentally friendly technologies during its life-cycle, with renewable energy. Renewable energy isn't abundant in all countries given its variation from one region to another, thus coal can be a complimentary element to reach the expected energy outcome.

One of these examples is the trend towards hydrogen-based systems; where electricity is produced using hydrogen via gas turbines and fuel cells. Given that hydrogen doesn't occur naturally as a gas, as it is combined with other elements, it has to be manufactured. Coal can be a supporting factor in the manufacturing of hydrogen through 'coal gasification'[4]. Moreover, coal can be used during any irregular power supplies or outages while leaving renewable energy for peak demands.

Sparing Lignite from the 1% heating usage

As highlighted above, 1% of lignite's usage is home heating. Given that anthracite is the cleanest version of coal and that it is mainly used in heating, among other uses, it's highly suggested that heating should be confined to anthracite only.

[4] The process of creating syngas - a mixture consisting of carbon monoxide, hydrogen, carbon dioxide, methane and water vapour – from coal and water, air and/or oxygen.

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