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Editorial

Outlook for the coal industry and new coal production technologies

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Historically, energy resources have evolved from high carbon to lower carbon fuels (from coal to oil to natural gas), then to non-carbon (hydroelectric, geothermal, wind power and solar). This dynamic process has reflected the evolution of human civilization and industrialization. As one of the most useful and classical energy resources, what is the outlook for the coal industry in the future? What factors will have a great impact on the outlook? Can new technologies in coal production make the coal industry cleaner and more competitive and increase its demand in the world market? How effective are CO_2 capture technologies for coal power plants? This editorial work attempts to provide insights into these issues.

1. The future outlook for the coal industry

Limiting global warming to 2 °C versus pre-industrial levels would imply reducing carbon dioxide (CO_2) emissions by 80% of the 1990 level by 2050 and a net-zero emission by the end of this century. To make this happen requires a fast transition of traditional fossil fuels to renewable energy such as wind and solar. In this framework, coal demand is expected to decline by about 8% by 2030 compared to the pre-crisis level in 2019. Advanced economies will cut their demand by 45% compared to 2019. China is still the largest consumer and producer, and the coal usage in China is expected to rebound in the near term and achieve its peak around 2025 followed by a gradual decline after 2025. In the Asia Pacific area, India, Indonesia and Southeast Asian countries will increase their coal demand for power and industrial usage in the next decade (IEA, 2020). By 2030 the global coal demand is projected to decrease by about 400 million tonnes of coal equivalent compared to 2019.

2. The impact of major factors on the outlook

Environmental concerns to reduce CO_2 emissions from coal-fired plants, declining coal usage in the power sector due to renewables expansion and a cheap natural gas price, and policies that phase out coal to achieve carbon neutralities are the three major factors leading to the coal market downturn. The power sector accounts for nearly 65% of coal demand. By 2030, advanced economies will consume 50% less coal compared to their level in 2019 mainly due to policy-driven requirements. The increasing supply of renewables and natural gas has diversified the power generation sources, and significantly reduced the coal usage in this sector. Coal is the largest source of CO_2 emissions and will be responsible for approximately 38% of the global CO_2 emissions from 2020 to 2030. The policy-driven changes are significantly affecting coal usage worldwide (IEA, 2020; IMF, 2020).

3. Development of new technologies in the coal industry

Potential technologies are emerging in the coal industry, such as hydraulic fracturing to improve the coalbed methane production; the CO_2 capture, utilization and sequestration (CCUS) to reduce CO_2 emissions from coal combustion; the

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coal-to-liquid and coal-to-gas fuel conversion technologies to improve the fuel efficiency and reduce the CO_2 emissions; internet of things, big data analytics, artificial intelligence, and automation to reduce operational costs and improve safety concerns and production efficiency in coal operations; and, underground coal gasification (UCG) to recover un-minable coal. Particularly, UCG has been attempted for over a century, and has not yet achieved a commercial-scale development. Successful development and utilization of this technology would make the coal industry more competitive and increase its demand in the world market. A UCG operation consists of a series of injection and production wells drilled into a coal seam; the coal is ignited after certain air and/or oxygen is injected. Chemical reactions convert the coal to syngas by pyrolysis, combustion and gasification reactions in a manner similar to those processes in a surface gasifier. The produced syngas is a mixture of mainly carbon monoxide and hydrogen, which can be used as fuel for power generation and feedstock for various chemical products (i.e., hydrogen and ammonia) (Nourozieh et al., 2010; Seifi et al., 2015). The carbon captured during syngas utilization can be used for enhanced oil recovery.

Emissions from syngas combustion are generally cleaner and less greenhouse gas emissions than coal-fired facilities. The UCG process is less costly than conventional surficial coal gasification because no coal mining, processing and transport are required, and no ash and slag removal or disposal is necessary. The environmental impact of UCG is relatively low compared to surficial gasification, as major disturbances in landscape and surface disposal of ash and coal tailings are not required. A properly designed UCG site will recognize and address potential groundwater pollution and subsidence issues; tests related to the cap rock integrity and highly cemented wells should be performed to avoid these issues. UCG can have obvious advantages compared with other in situ coal applications, including mining, coalbed methane exploration and development; the cavities after UCG can be used as CO_2 storage (Jiang et al., 2019).

4. CO_2 capture technologies for coal power plants

Five main types of CO_2 capture technologies from flue gas are proven. The average capture efficiency is from 80% to 90%. Cryogenic separation can provide the highest capture efficiency up to 99.99%. The CO_2 capture step represents 70-80% of the overall CO_2 capture and sequestration costs. Economic analysis shows that US $70-100 are needed to capture one tonne CO_2 from flue gas (the average CO_2 concentration is about 3-14%) on average. On the other hand, it costs between US $300 to $1,500 to capture CO_2 directly from air (Brandl et al., 2021). It would be possible to commercialize the capture efficiency beyond 90%. However, operators are not able to make benefits under the current policies because of the high associated capital and operational costs. The capture approaches include post-combustion, pre-combustion, oxyfuel combustion, chemical looping combustion and from air. The post-combustion technology is a mature technology, and has been widely applied. Future CO_2 capture technologies are likely to focus on hybrid capture technologies, such as integrated CO_2 capture and conversion. The coal use in the power sector surpassed 10 Gt CO_2 emissions globally in 2018, and a successful application of carbon capture technologies can help the world reduce up to 8-10 Gt CO_2 emissions annually. CCUS has received much research attention over the past two decades.

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Conflict of interest

The authors declare no competing interest.

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