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IEO2021 Issues in Focus: Uncertainty in Coal Trade in India and Greater Southeast Asia

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Executive Summary

This analysis provides insight on world coal trade dynamics based on three cases varying demand and supply in India and Greater Southeast Asia (GSEA)[1] from our *International Energy Outlook* 2021 (IEO2021) Reference case.

- Reduced coal demand. When we reduced coal demand in India by 33% from our IEO2021 Reference case, we found that coal production in India declines by 42% and imports decrease by 9%. Similarly in GSEA, a 37% decrease in coal demand in 2050 results in domestic coal production declining by 34% and the amount of coal imported into the region falling by 53%.
- Increased coal supply (decreased coal production costs). When we decreased coal production costs by 50%, domestic coal supply increased by 34% in India and 30% in GSEA, and coal consumption increased by about 15% in both regions. Coal imports into India decreased by 32% and GSEA decreased by 44% in 2050.
- Decreased coal supply (increased coal production costs). When we increased coal production costs in the region by 50%, we saw a 35% and 20% decrease in domestic coal supply in India and GSEA, respectively. Both India and GSEA see a roughly 15% decrease in coal consumption in 2050. Coal imports into India and GSEA in 2050 increased by 32% and 7%, respectively.

Coal remains a reliable, affordable source of energy for non-OECD Asia. However, many recent developments contribute to the uncertainty of coal's future, such as falling renewable energy costs and environmental concerns. In this analysis, we explore three cases and the impact that changes in coal demand and production costs can have on electricity generation, coal trade, and carbon dioxide (CO_2) emissions.

In this analysis, we consider India and GSEA. The first case assumes policy or technology changes resulting in a 33% decrease in coal demand in the industrial and electric power sectors. The other two cases increase or decrease the cost of coal production—and consequently decrease and increase coal supply, respectively—in India and GSEA by 50% compared with the costs assumed in the IEO2021 Reference case.

This analysis provides insight on world coal demand dynamics. If coal demand in India decreases below 2050 Reference case levels, coal production in India—and to a lesser extent, coal imports into India—will decrease. In GSEA, reduced coal demand results in decreased domestic coal production and a significant decrease in coal imports.

Beyond impacts from decreased coal demand, we also examine two cases where the costs of coal production were either increased or decreased in India and GSEA. When coal production costs increased, we saw a decrease in domestic coal supply and coal demand in India and GSEA. Correspondingly, when coal production costs decreased, domestic coal supply and coal demand increased in the two regions. Coal imports into India and GSEA either increased or decreased in

[1] We define Greater Southeast Asia (GSEA) as the Association of South Asian Nations countries of Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam; plus the Indo-Asia countries of Nepal, Bhutan, Bangladesh, Sri Lanka, and the Melanesia, Micronesia, and Polynesia countries of the South Pacific. The GSEA countries are a subset of the other non-OECD region that is modeled in the World Energy Projection System (WEPS) and excludes Afghanistan, Mongolia, North Korea, and Pakistan. The five largest coal-consuming countries in this region are Indonesia, Vietnam, Malaysia, the Philippines, and Thailand.

response to production as coal production costs changed. Coal-generated CO_2 emissions correspondingly changed proportional to coal consumption in India and GSEA, illustrating that changes to coal consumption or coal production cost can alter CO_2 emissions.

Introduction

For many countries in Asia, domestically produced coal provides an affordable, abundant, and reliable energy resource. For economies such as those in India and Indonesia, which have ample coal reserves and abundant labor, domestically produced coal has been among their cheapest source of energy. Coal in these economies is often sold at or below production cost to subsidize electricity generation or other energy needs. The governments of these countries often have controlling ownership interest in electricity generation, coal production, or coal transport by rail.[2] Existing climate policies in this region of primarily non-OECD countries don't limit coal use to the extent that OECD climate policies do. However, coal's share of the future generation mix in this region is less certain because of air quality concerns, increased scrutiny of greenhouse gas emissions, and declining costs of renewable generation sources (for example, wind and solar). Although China has strongly supported growth of coal-fired power generation in Asia over the past 10 years by providing investment through its Belt and Road Initiative,[3] it plans to consider environmental concerns in the second Belt and Road Initiative, which may limit investment sources for fossil fuel projects in the future.

Although much of the world is focused on reducing coal use, many developing countries in Asia remain strongly tied to coal for electric power and industrial output. In 2020, coal fueled two-thirds of India's electricity generation. India is also the world's second-largest importer and consumer of metallurgical coal for raw steel production. Developing countries in Asia have immediate needs for sufficient coal supply to meet coal demand for both currently operational plants and those under construction. As coal demand grows, countries rely on imports when domestic supply is insufficient. Although new renewable generation from wind and solar sources will ultimately reduce the need for coal-fired generation and alternative industrial processes may reduce the need for coal-produced direct reduced iron (DRI),[4] the challenges facing these developing economies and their coal supply chains are still significant.

In this analysis, we examine three alternative cases and how their differing factors affect the electricity generation mix, coal production, and coal trade between India and Greater Southeast Asia (GSEA).[5] The first case assumes policy or technology changes resulting in a 33% decrease in coal demand in the industrial and electric power sectors. Another case increases the cost of coal production in India and GSEA by 50% compared with the costs assumed in the IEO2021 Reference case, consequently decreasing coal supply. A third case decreases the cost of coal production in the region by 50%. These

[2] Why is India facing a coal shortage?, Reuters, October 1, 2021.

[3] China Hits Reset on Belt and Road Initiative, Voice of America, October 30, 2021.

[4] Direct reduced iron is the product of the direct reduction of iron ore in the solid state by carbon monoxide and hydrogen derived from natural gas or coal.

[5] We define Greater Southeast Asia (GSEA) as the Association of South Asian Nations countries of Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam; plus the Indo-Asia countries of Nepal, Bhutan, Bangladesh, Sri Lanka, and the Melanesia, Micronesia, and Polynesia countries of the South Pacific. The GSEA countries are a subset of the other non-OECD region that is modeled in the World Energy Projection System (WEPS) and excludes Afghanistan, Mongolia, North Korea, and Pakistan. The five largest coal-consuming countries in this region are Indonesia, Vietnam, Malaysia, the Philippines, and Thailand.

cases show the breadth of the uncertainty facing international coal use and facing those companies and countries that supply, trade, consume, and regulate coal as an energy commodity.

This analysis provides insight on world coal demand dynamics. If coal demand in India is reduced 33% below 2050 Reference case levels, coal production in India will decline 42%, and India's coal imports will decrease by 9%. Similarly in GSEA, a 37% decrease in coal demand in 2050 results in domestic coal production declining by 34% and coal imported into the region falling by 53%.

When coal production costs in India and GSEA were increased, we saw a 34% decrease in domestic coal supply and a 16% decrease in coal demand in India, and a 20% decrease in coal supply and 15% decrease in demand in GSEA by 2050. Coal imports into India and GSEA increased by 30% and 26%, respectively, when higher cost coal resulted in decreased coal production. Correspondingly, in the case where coal production costs were decreased, domestic coal supply increased by 34%, and coal demand increased by 15% in India, with similar increases in GSEA of 30% for supply and 16% for demand.

Market description

India is the second-largest producer of coal in the world behind China, and the second-largest coal consumer behind China. In 2018, India consumed 986 million short tons (MMst) of coal, and nearly 80% of that was produced from domestic coal mines. To make up the shortfall in domestic supply, India imported 247 million short tons of coal from Indonesia (supplying approximately 50% of India's coal imports) and other GSEA countries.

Indonesia is the largest coal producer among the countries in GSEA, and is the only country in GSEA where net coal exports (exports less imports) are greater than zero. As such, Indonesia's coal exports are large enough that they make the entire GSEA region a net exporter of coal. Indonesia's production, consumption, and exports of coal have grown significantly over the past 20 years. We reported[6] that Indonesia produced 615 MMst, consumed 127 MMst, and exported of 473 MMst of coal in 2018—an increase of more than 300% in all categories since 2000, when it produced 94 MMst, consumed 27 MMst, and exported 63 MMst of coal. Today, Indonesia is the largest exporter of steam coal in the world, and the world's fourth-largest coal producer, surpassing Russia and Australia. Indonesia is also the largest coal consumer in the region, accounting for 30% of the 438 MMst consumed by the region in 2018. Taiwan (18%), Malaysia (9%), Vietnam (16%), and the Philippines (8%) also consumed significant amounts of coal in GSEA in 2018, which continues into the present.

Coal has been a cheap source of energy for both OECD and non-OECD countries for many years. It has a well-established presence in the industrial sector (for example, in concrete and steel production), as well as the electric power sector, where significant investment has been made both in coal-fired power plants and in maintaining the coal supply chain. Although wind and solar generation could greatly expand access to electricity, the barriers to switching away from coal may be more significant in countries with established coal mining and coal power generation assets and infrastructure.

As many large developed economies reduce coal use (such as in the United States and OECD Europe), the developing economies in India and GSEA are areas where growth in coal demand is possible. China and India, specifically, have invested heavily in coal power, citing energy security and domestic employment as reasons behind the continued growth in coal-fired generating capacity.

[6] EIA International Energy Statistics, Coke and Coal Annual data by country

Indonesia's political environment makes growth in coal production likely to continue, while foreign investment in the country's coal-fired power plants also persists. Developing countries sometimes face global environmental pressure to switch from coal-fired generation to renewable power; many leaders in Asia have expressed this switch as a future goal, but not much has changed so far. In 2021, global coal consumption increased after the lows in 2020 following the COVID-19 pandemic, and Asia and the world had the highest nominal coal prices in 10 years.

Case description

This analysis explores three cases where we adjusted the long run market conditions for coal demand or coal supply costs and examined how the regional electricity and coal markets will rebalance, particularly in India and the GSEA region. Within the WEPS[7] integrated market framework, we developed alternative scenarios targeting the coal market in India and GSEA between 2030 and 2050 and left all other model drivers unchanged from the Reference case. The primary tool for this analysis was our new International Coal Market Module (ICMM), but we ran all other fuel market and transport modules along with the coal module, including the International Electricity Market Module, which provides electric power generation by fuel type and region.

The ICMM replaces a previous exogenous process for coal pricing with a module that endogenously determines coal prices for all sectors using an interregional-trade modeling framework.[8] This framework also changed the representation of international coal production to use WEPS regions and sub-regions based on coal supply curves by coal type. ICMM finds the least-cost transport and supply solution where coal supply (by region and coal type) is balanced with coal demand. Coal production capacity growth or contraction is allowed under controlled limits based on production capacity utilization by region. Coal trade is determined in physical units (metric tons) by coal type.

We ran three cases to explore the uncertainty in future coal demand and supply. These cases are not intended to serve as predictions of a probable future, but rather, to help illustrate key factors that may contribute to potential future outcomes given the uncertainty of policy and economic factors affecting coal consumption and supply. All other assumptions not discussed here are the same as those in the IEO2021 Reference case:

- **Low Coal Demand case:** In this case, demand for coal in India and GSEA is lower than in the IEO2021 Reference case. This case represents a world where increasing coal consumption in any sector is not desirable, regardless of the cost of coal compared with other electric power fuels or the demand for coal in industrial processes, such as steel production. This reduced demand is achieved by changing input assumptions in the industrial and electric power sector modules to reduce coal consumption and does not reflect any specific planned or expected changes in government policy. Instead, reduced demand could represent a number of policy or market drivers designed to decrease coal demand. In 2050, this case has 33% lower demand than the Reference case in India and 37% lower in GSEA, and we did not change ICMM's base assumptions for coal production cost. In addition, coal demand growth does not disappear from this case because coal use is still expected to grow in these developing regions—although at a much slower rate. The lower coal demand may result in slightly lower coal prices and a new mix

[7] World Energy Projection System (WEPS), Handbook of Energy Modeling Methods
[8] *International Energy Outlook 2021* Fact Sheet: International Coal Market Model

of coal trade as the coal module finds a new equilibrium with different regional coal supply (based on price and quantity relationships) and coal trade solutions.

- **High Coal Supply case:** This case leaves the assumptions for the drivers of coal demand unchanged from the IEO2021 Reference case, but it allows coal supply to grow faster in India and GSEA. This increased growth is created by decreasing the cost of coal production by 50% in India and GSEA to make coal production cheaper at all quantities. This supply shift could come from mining technology or labor productivity changes that lower mining costs, or it could represent the removal of barriers that prevent coal production from expanding into new reserves not previously mined. Lower coal commodity costs result in greater amounts of available domestic coal supply.

- **Low Coal Supply case:** This case leaves the assumptions for coal demand drivers unchanged from the IEO2021 Reference case. However, it reduces the available coal supply in India and GSEA by increasing the cost of coal production by 50% and increasing the price at all quantities to make coal production more expensive. This case represents possible higher labor costs, excise taxes, or restrictions on coal production expansion into new reserves not previously mined. Given higher coal costs, less domestic coal supply is available in India and GSEA.

Although some supply uncertainty may also exist in terms of the coal resource base and economic reserves available in India and GSEA, we did not assume any long run supply limits in any of the cases. We assumed India and Indonesia have over 100 years' worth of coal reserves at current production levels.

Results and discussion

Change in electricity generation mix

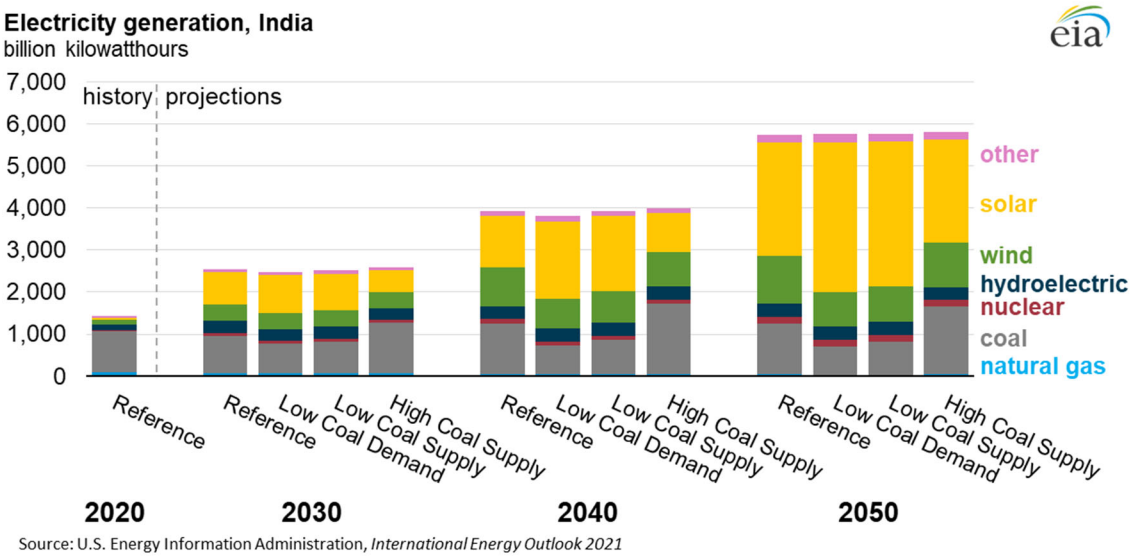
Although the overall level of electricity generation is relatively stable across the cases, the fuel mix varies. In all cases, coal-fired generation in India, historically the most prevalent fuel for electricity, is displaced by renewable sources of electricity, such as solar and wind, through the projection period (Figure 1). This trend is less evident in GSEA, where coal remains the prevalent generation source across all cases, despite growth in other generation sources (Figure 2).

Because of the strong growth of wind and solar generation we expect in India, we project that the share of generation from coal in the Reference case will decline to 21% in 2050, down from 67% in 2020. In the Reference case, coal's share of generation in GSEA grows to 47% in 2050 from 36% in 2020. For India, solar power increases and becomes 47% of the generation mix and 14% of the mix in GSEA in 2050 in the Reference case. In 2020, solar accounted for 3% of India's total generation and 1% of GSEA's. Wind-powered generation contributes 20% to the generation mix in India and 7% in GSEA in 2050 in the Reference case.

Natural gas is relatively expensive in both of these regions, and it does not significantly respond to changes in coal-fired power generation. Although GSEA has developed oil and natural gas resources for domestic use and export over the past century, India has very little domestic natural gas that it could develop, and so natural gas production is unlikely to expand in either region. In India, natural gas-fired generation decreases from 6% of generation in 2020 to 1% of the generation mix in 2050. In the

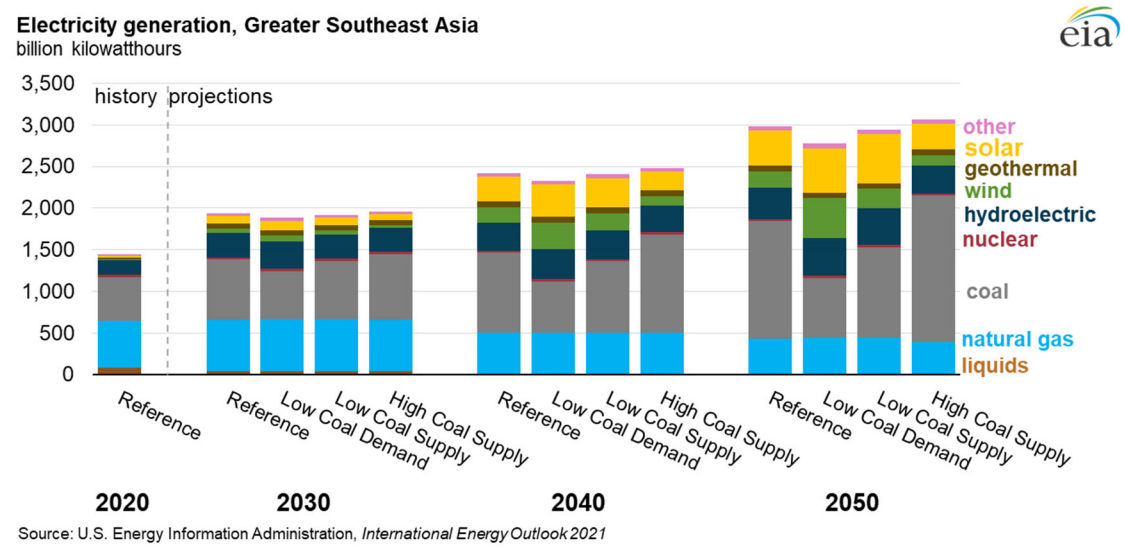
Reference case in GSEA, natural gas-fired generation decreases from a 39% share of generation in 2020 to a 14% share in 2050. In India, hydropower's share of generation declines from 10% in 2020 to 5% in 2050, while in GSEA hydropower's share increases from 12% in 2020 to 13% in 2050.

Figure 1.



Source: U.S. Energy Information Administration, *International Energy Outlook 2021*

Figure 2.



Source: U.S. Energy Information Administration, *International Energy Outlook 2021*

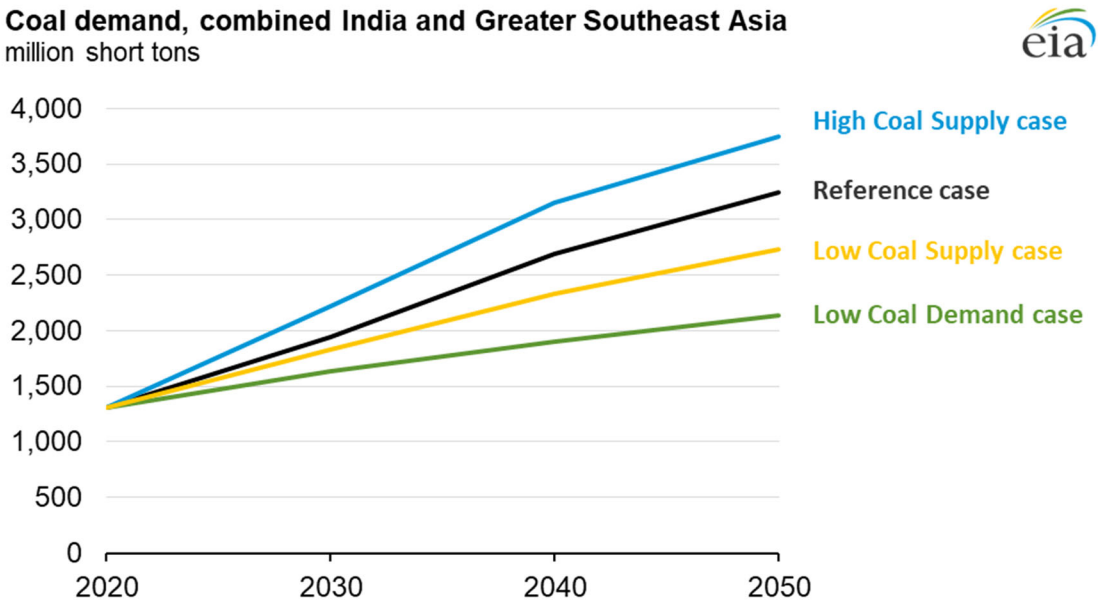
In both the Low Coal Demand and Low Coal Supply Growth cases, growth in solar generation accounts for the majority of the lost coal share in both India and GSEA. In 2050 in those cases, solar generation provides about 60% of the generation in India and an almost 20% share in GSEA. In contrast, in the High Coal Supply case, coal has a larger share in 2050 than in the Reference case, contributing 28% of the generation mix in India and 58% in GSEA, while solar accounts for 42% of generation in India and 10% in GSEA. In the Low Coal Demand and Low Coal Supply Growth cases, about 85% of all generation in 2050

comes from renewable sources in India, compared with 75% in the Reference case and 69% in the High Coal Supply Growth case. For GSEA in 2050, renewable generation shares range from 29% in the High Coal Supply case to 57% in the Low Coal Demand case. Because of the significant mismatch in timing between electricity supply and demand in a solar-dominated grid, these cases also result in significant development of energy storage resources.

Change in coal demand

The Low Coal Demand case has about 35% less coal demand in India and GSEA, while the High Coal Supply results in 15% more coal demand and the Low Coal Supply case results in 16% less demand relative to the Reference case in 2050 (Figure 3).

Figure 3.

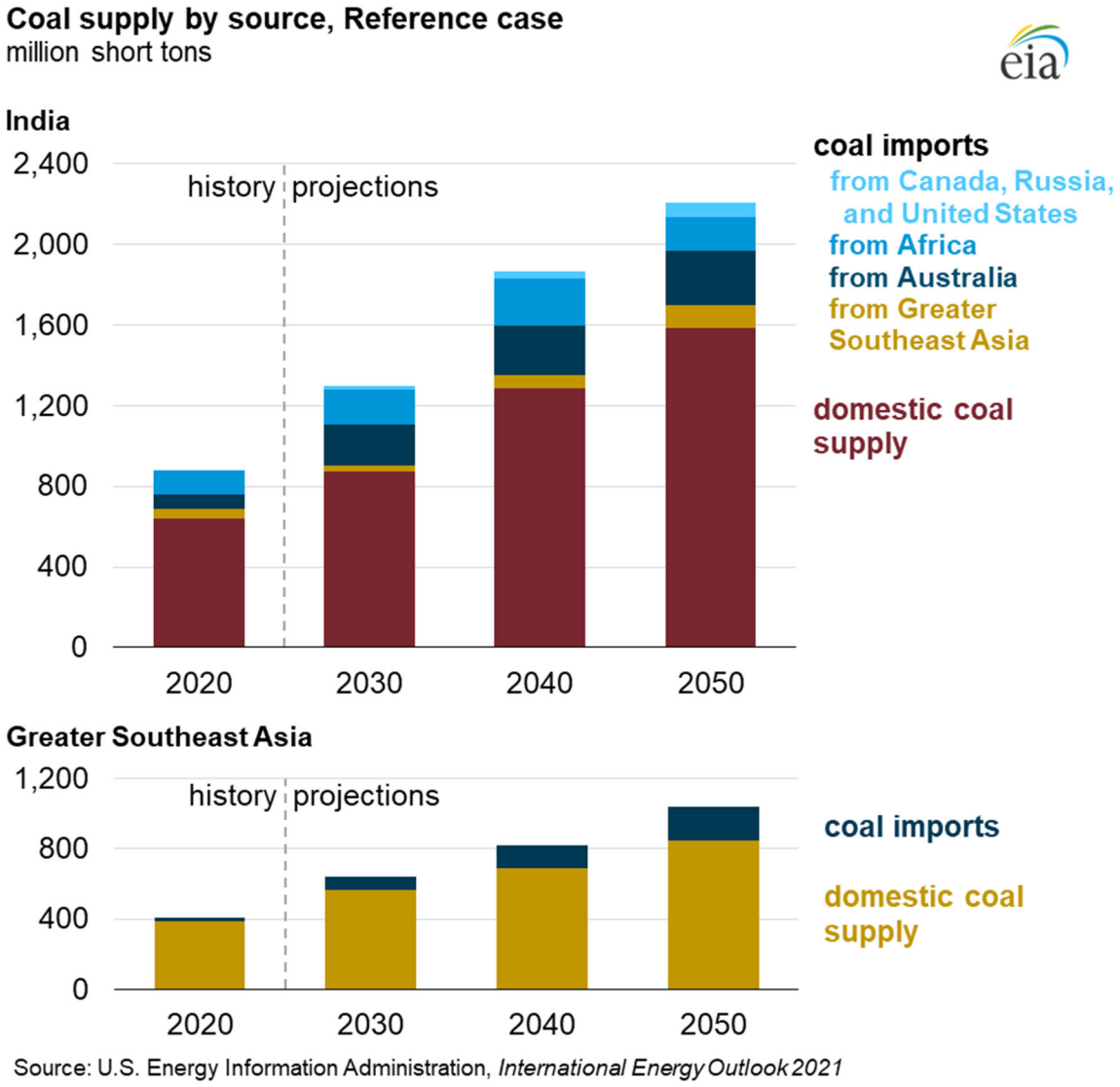


Source: U.S. Energy Information Administration, *International Energy Outlook 2021*

Coal supplied from production and imports

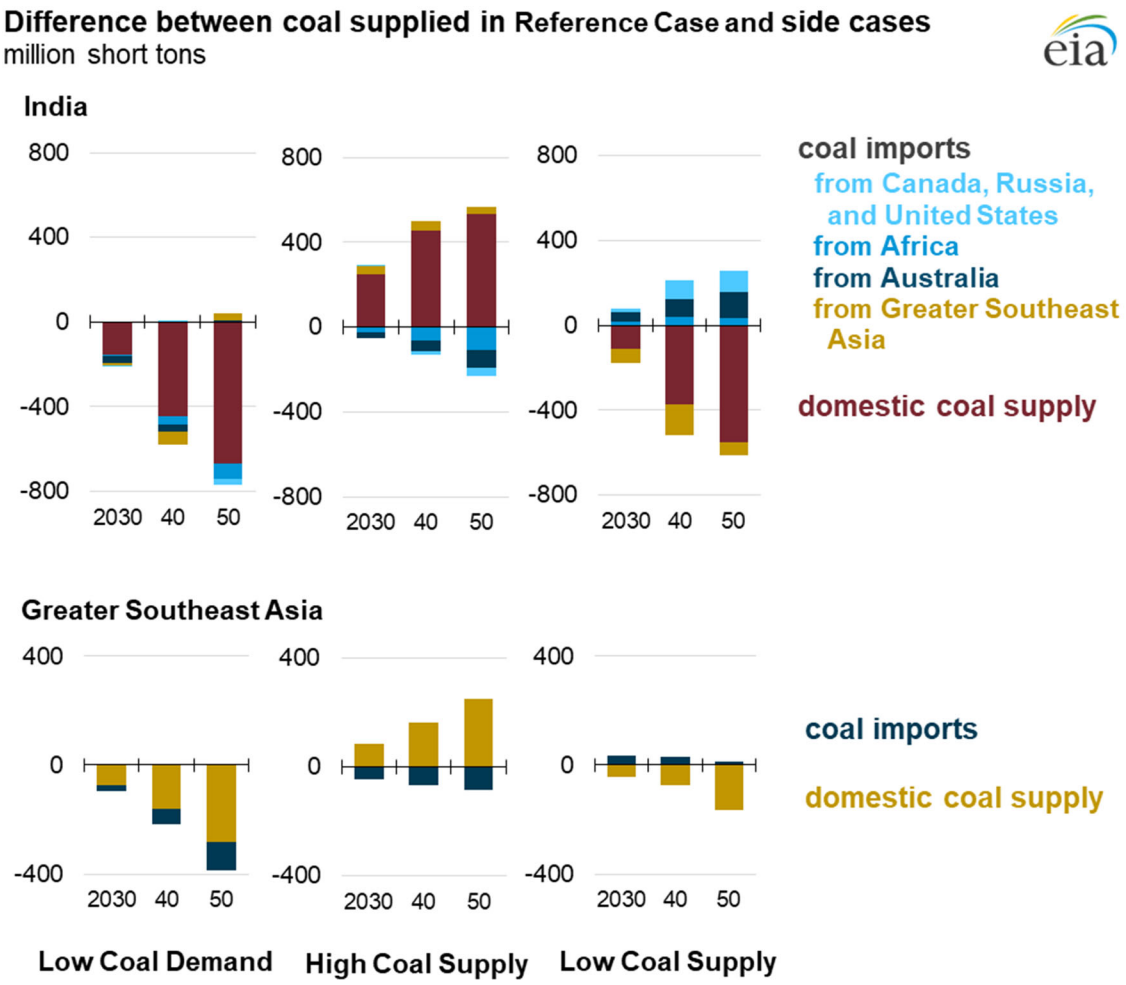
India and GSEA get most of their coal supply from domestic supply (production excluding exports) and then import to fulfill any remaining demand. In the IEO2021 Reference case, coal consumption in India and GSEA together grow by over 3% per year, and both regions combined consume 3,245 million short tons (MMst)—about 35% of the world's coal demand—in 2050. Both increasing domestic production and imports meet this growth in consumption (Figure 4). Detailed coal trade for the Reference case is in Appendix Table 1.

Figure 4.



Source: U.S. Energy Information Administration, *International Energy Outlook 2021*

Figure 5.



Source: U.S. Energy Information Administration, *International Energy Outlook 2021*

Low Coal Demand case

As a result of reduced demand in this case, coal production decreases in 2050 by 42% in India and 23% in GSEA, relative to the Reference case (Figure 5). In addition, imports into India decline by 9% in 2050, and imports into GSEA decline by 53%, relative to the Reference case. Imports declined because the need for imported metallurgical coal is reduced and domestic coal supplies a greater share of steam coal demand. Reduced coal demand in GSEA results in more coal produced in GSEA being traded to India, displacing the growth in imports from Africa into India that occurred in the Reference case. In 2050, with a combined 1,113 MMst decrease in coal demand, India produces 668 MMst less coal, GSEA produces 240 MMst less coal, and 161 MMst less coal is traded into these regions. Detailed trade for other years is available in Table 2 of the Appendix.

By 2050, the Low Coal Demand case results in 2,132 MMst of coal consumed in India and the GSEA, or about 1.1 billion fewer tons than in the IEO2021 Reference case in 2050. This decrease is nearly equivalent to the total increase in world coal demand seen in the Reference case, in which world coal demand increases by 1.2 billion short tons between 2020 and 2050. Although India and GSEA still have significant coal demand growth in the Low Coal Demand case, this case shows a type of targeted effort

to reduce coal demand that would be required to stop or slow growth in world coal demand—particularly in the electric power and industrial sectors—as called for in international climate agreements, such as the Paris Agreement.[9]

High Coal Supply case

The High Coal Supply case shows the results of reducing the cost of coal supplied in India and GSEA by 50% from 2030 to 2050. Lower delivered prices drive a 15% increase in coal demand in 2050 in India and 16% in GSEA relative to the Reference case. This demand response is primarily in the electric power sector as lower-cost coal dispatch displaces other generation types. The industrial sector is not very responsive to coal price, but rather, it is driven primarily by demand for steel and other products that use coal. In addition, we did not change any macroeconomic assumptions in this case. The lower coal prices in this case result from a 34% increase in domestic supply in India and 30% in GSEA in 2050, which displaces coal imports into both regions.

Exports to India greatly decrease in this case. Exports from Africa to India (mostly steam coal) decrease by 94% in 2050. Exports from more distant regions—such as Canada, Russia, and the United States—are reduced by 57% in 2050. Metallurgical coal exports from Australia into India remain relatively stable throughout the projection period, but total coal exports from Australia (both steam and metallurgical coal) decrease by about 32% in 2050. GSEA, which also has a cheap coal supply in this case, increases steam coal trade into India by 21% in 2050, contributing to the displacement of other coal imports into India.

In the High Coal Supply case, we decreased the price in the coal supply curves for India and GSEA by 50% to simulate a reduced cost in production. This assumption does not take into account coal reserves or the potential cost and quality of undeveloped coal resources in these regions. The price impact in India results in lower coal prices of $1.00 to $1.15 per million British thermal units (MMBtu) (2015$) in all analysis years from 2030 through 2050. The delivered coal prices in GSEA are lower by $0.75/MMBtu to $0.95/MMBtu (in 2015$) in all analysis years. In 2050, as a result of the lower supply costs, India's coal production increases by 533 MMst (34%) and GSEA is 331 MMst (32%) greater than in the Reference case. We project that the combined coal consumption for India and GSEA is 3,745 MMst—500 MMst greater than in the Reference case—in 2050. The cheaper coal supply also results in GSEA's exports that are 80 MMst higher than in the Reference case in 2050. Detailed trade for other years of the High Coal Supply case is available in Table 3 of the Appendix.

Low Coal Supply case

In the Low Coal Supply case, we increased the average cost in the coal supply curves for India and GSEA by 50% from 2030 to 2050 to impose higher costs on coal production. Higher delivered coal prices drive a 16% decrease in coal demand in India and 15% in GSEA in 2050. As with the High Coal Supply case, the demand response is primarily in the electric power sector as coal-fired generators are dispatched less frequently under higher coal prices and other generation resources, such as solar power, displace coal-fired generation. Demand in the industrial sector—which is not very responsive to coal price—changes minimally because only coal supply assumptions were changed and we did not adjust any macroeconomic assumptions. The higher coal prices in this case result in domestic supply that is 35% lower in India and 20% lower in GSEA in 2050. With domestic coal production costing more in India, coal imports increase by about 31% in 2050, but the trade mix shifts away from GSEA because, like India, coal

[9] United Nations Paris agreement.

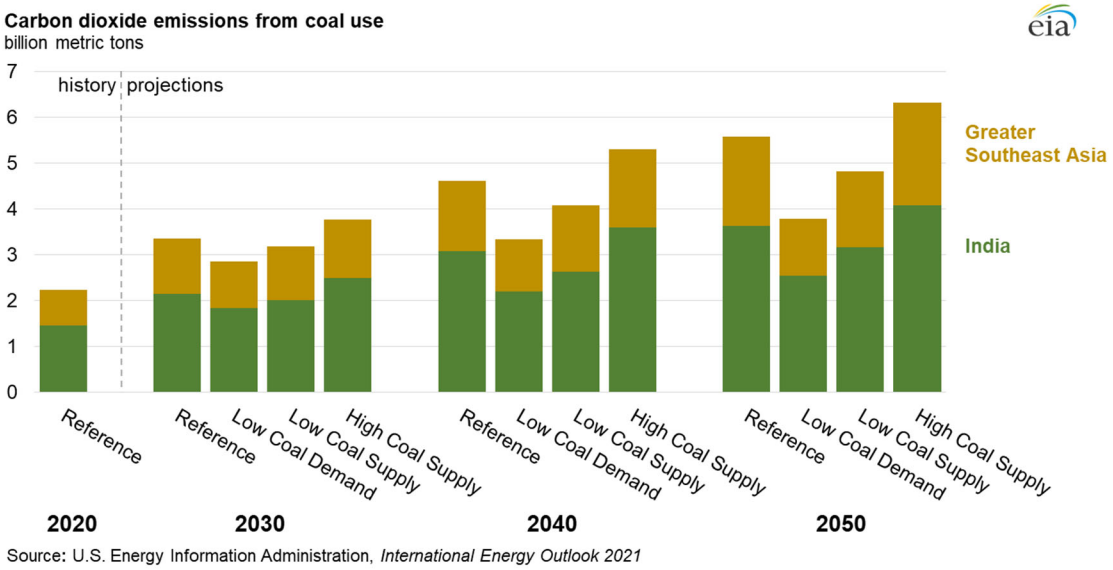
from that region is now produced at higher costs. Imports to India in 2050 from Africa increase by 30% and from Australia by 47%, while trade from GSEA to India decrease by 37%. Imports into India from Canada, Russia, and the United States increase to 171 MMst (137%) in 2050 from relatively low levels of 72 MMst per year in the Reference case. Because GSEA is also producing coal at a higher cost, coal imported into GSEA from outside the region increases by 9% in 2050.

The Low Coal Supply case could represent declining coal resource quality, a new tax on coal production, or an upward shift in labor costs, but it does not represent any specific proposed policy or resource quality assumption. The delivered price impact in India results in a coal price of $0.80/MMBtu to $0.90/MMBtu (2015$) higher in 2030 to 2050. We project the delivered coal prices in GSEA to be from $0.60/MMBtu to $0.70/MMBtu (2015$) higher in 2030 to 2050. In 2050, with higher supply costs, India's production is lower by 551 MMst (35%) lower than in the Reference case, and GSEA is lower by 230 MMst (22%). The combined coal consumption for India and GSEA is 510 MMst (16%) lower than Reference case coal consumption. Detailed trade for other years of the Low Coal Supply case is available in Table 4 of the Appendix.

Impact on CO_2 emissions

The Low Coal Demand and Low Coal Supply cases illustrate how targeted changes to limit coal consumption levels or increase coal production costs could reduce future CO_2 emissions from coal, while lower coal production costs in the High Coal Supply case could lead to increased CO_2 emissions. CO_2 emissions in India and the GSEA in the Reference case grow from 2.2 billion metric tons of CO_2 produced from coal in 2020 to 5.6 billion metric tons in 2050 (Figure 6). Regional CO_2 emissions from coal in the Low Coal Demand case reach 3.8 billion tons in 2050, 32% lower than 2050 Reference case levels. The Low Coal Supply case reaches 4.8 billion metric tons of regional coal CO_2 emissions, 13% lower than the Reference case in 2050, while the High Coal Supply case reaches 6.3 billion metric tons, a 13% increase over the Reference case in the same year.

Figure 6.



Source: U.S. Energy Information Administration, *International Energy Outlook 2021*

Conclusion

Under existing market conditions and current laws and regulations, coal remains a significant source of energy, and is dominant in many areas of the world. Coal maintains a prominent role in filling the energy needs of the approximately two billion people in India and GSEA, where, with limited policy intervention, we project that domestically produced coal will remain a critical piece of the energy mix needed to supply electric power and industrial heat.

In this analysis, we examined some degree of supply uncertainty by changing coal supply costs, and we found that when the energy mix changed with lower or higher coal costs, the energy markets adjusted, and international coal trade shifted to keep coal markets in balance for all cases.

The Low Coal Demand case represents a world where growth in coal demand slows. In this case—where coal demand decreases by 33% in India and 37% in GSEA from the Reference case by 2050—the combined coal demand of India and GSEA reaches 2,132 MMst by 2050. However, coal demand in the Reference case is already near the 2 billion ton level by 2030, underscoring the fact that this lowered demand would likely require significant policy changes in these developing Asian countries. Lower coal demand in this case results in a 32% reduction of regional coal-related CO_2 emissions in 2050 compared with the Reference case.

In the High Coal Supply case compared to the Reference case, coal consumption in 2050 increases by 15% in India and GSEA, and in the Low Coal Supply case, coal consumption decreases by 15%. However, in both of these supply cases, coal demand more than doubles by 2050 from 1,302 MMst in 2020. Coal demand in 2050 in the High Coal Supply case is 3,245 MMst and 2,736 MMst in the Low Coal Supply case. In the High Coal Supply case, regional coal-related CO_2 emissions rise by 13% over the Reference case in 2050; however, in the Low Coal Supply case, regional coal-related CO_2 emissions in 2050 fall by 13% as compared to the Reference case.

We implemented a new module of international coal production and trade to better understand coal's contribution to the energy mix and the economic, technological, and policy factors affecting the coal market. We developed our new International Coal Market Module to better understand these relationships and their impact on related markets, such as electric power generation. This analysis using that module shows that coal trade responds accordingly to changes in coal costs—more coal is produced from domestic sources with lower costs, and less coal is produced domestically when supply costs are higher. In addition, changes in coal demand in a single country or region can have significant implications, not just for production within that region, but for production and trade across the globe. Changes in the cost of supplying coal in one region can affect consumption in other regions and result in a shift in trade patterns.

Appendix

Source: U.S. Energy Information Administration, *International Energy Outlook 2021*

Table 1. Reference case: India and Greater Southeast Asia (GSEA) coal demand and supply

million short tons

India Year	India total demand	Production (+)	Exports (-)	Domestic supply	Imports from Africa (+)	Imports from Australia (+)	Imports from GSEA (+)	Imports from Canada, Russia, and United States (+)	India total supply
2030	1,297	873	--	873	29	204	174	18	1,297
2035	1,580	1,072	--	1,072	38	238	207	26	1,580
2040	1,865	1,287	--	1,287	65	245	233	35	1,865
2045	2,145	1,510	--	1,510	93	257	222	62	2,145
2050	2,206	1,584	--	1,584	113	268	169	72	2,206

GSEA Year	GSEA total demand	Production (+)	Exports to India (-)	Exports to rest of Asia (-)	Domestic supply	Imports from Africa (+)	Imports from Australia (+)	Imports from Canada, Russia, and United States (+)	GSEA total supply
2030	642	775	174	37	564	9	61	8	642
2035	739	878	207	34	637	10	82	9	739
2040	821	959	233	35	691	11	108	10	821
2045	942	1,036	222	33	780	13	137	11	942
2050	1,039	1,047	169	32	845	14	162	18	1,039

Source: U.S. Energy Information Administration, *International Energy Outlook 2021*

Table 2. Low Coal Demand Case: India and Greater Southeast Asia (GSEA) coal demand and supply

million short tons

India Year	India total demand	Production (+)	Exports (-)	Domestic supply	Imports from Africa (+)	Imports from Australia (+)	Imports from GSEA (+)	Imports from Canada, Russia, and United States (+)	India total supply
2030	1,088	719	--	719	22	171	160	16	1,088
2035	1,188	780	--	780	31	186	158	33	1,188
2040	1,295	844	--	844	26	211	171	44	1,295
2045	1,393	883	--	883	27	250	185	48	1,393
2050	1,480	916	--	916	36	275	205	49	1,480

GSEA Year	GSEA total demand	Production (+)	Exports to India (-)	Exports to rest of Asia (-)	Domestic supply	Imports from Africa (+)	Imports from Australia (+)	Imports from Canada, Russia, and United States (+)	GSEA total supply
2030	545	682	160	33	490	8	39	8	545
2035	579	722	158	47	517	8	44	9	579
2040	601	747	171	44	531	9	51	10	601
2045	639	778	185	40	553	9	65	11	639
2050	652	807	205	40	561	10	69	13	652

percentage change from Reference case

India Year	India total demand	Production (+)	Exports (-)	Domestic supply	Imports from Africa (+)	Imports from Australia (+)	Imports from GSEA (+)	Imports from Canada, Russia, and United States (+)	India total supply
2030	-16%	-18%	--	-18%	-25%	-16%	-8%	-12%	-16%
2035	-25%	-27%	--	-27%	-17%	-22%	-24%	30%	-25%
2040	-31%	-34%	--	-34%	-61%	-14%	-26%	26%	-31%
2045	-35%	-42%	--	-42%	-70%	-3%	-17%	-22%	-35%
2050	-33%	-42%	--	-42%	-68%	2%	21%	-32%	-33%

GSEA Year	GSEA total demand	Production (+)	Exports to India (-)	Exports to rest of Asia (-)	Domestic supply	Imports from Africa (+)	Imports from Australia (+)	Imports from Canada, Russia, and United States (+)	GSEA total supply
2030	-15%	-12%	-8%	-12%	-13%	-12%	-36%	0%	-15%
2035	-22%	-18%	-24%	39%	-19%	-17%	-46%	0%	-22%
2040	-27%	-22%	-26%	27%	-23%	-21%	-52%	0%	-27%
2045	-32%	-25%	-17%	21%	-29%	-26%	-53%	0%	-32%
2050	-37%	-23%	21%	26%	-34%	-30%	-58%	-32%	-37%

Source: U.S. Energy Information Administration, *International Energy Outlook 2021*

Table 3. High Coal Supply Case: India and Greater Southeast Asia (GSEA) coal demand and supply

million short tons

India Year	India total demand	Production (+)	Exports (-)	Domestic supply	Imports from Africa (+)	Imports from Australia (+)	Imports from GSEA (+)	Imports from Canada, Russia, and United States (+)	India total supply
2030	1,532	1,121	--	1,121	5	176	212	18	1,532
2035	1,939	1,449	--	1,449	1	194	276	19	1,939
2040	2,236	1,741	--	1,741	1	196	279	19	2,236
2045	2,394	1,969	--	1,969	7	193	205	20	2,394
2050	2,541	2,116	--	2,116	7	182	205	31	2,541

GSEA Year	GSEA total demand	Production (+)	Exports to India (-)	Exports to rest of Asia (-)	Domestic supply	Imports from Africa (+)	Imports from Australia (+)	Imports from Canada, Russia, and United States (+)	GSEA total supply
2030	682	927	212	65	650	9	15	8	682
2035	801	1,113	276	84	753	11	28	9	801
2040	915	1,228	279	94	855	12	37	10	915
2045	1,064	1,277	205	86	986	14	53	11	1,064
2050	1,205	1,378	205	77	1,097	15	80	13	1,205

percentage change from Reference case

India Year	India total demand	Production (+)	Exports (-)	Domestic supply	Imports from Africa (+)	Imports from Australia (+)	Imports from GSEA (+)	Imports from Canada, Russia, and United States (+)	India total supply
2030	18%	28%	--	28%	-83%	-14%	22%	1%	18%
2035	23%	35%	--	35%	-97%	-19%	33%	-27%	23%
2040	20%	35%	--	35%	-98%	-20%	20%	-46%	20%
2045	12%	30%	--	30%	-92%	-25%	-8%	-68%	12%
2050	15%	34%	--	34%	-94%	-32%	21%	-57%	15%

GSEA Year	GSEA total demand	Production (+)	Exports to India (-)	Exports to rest of Asia (-)	Domestic supply	Imports from Africa (+)	Imports from Australia (+)	Imports from Canada, Russia, and United States (+)	GSEA total supply
2030	6%	20%	22%	76%	15%	4%	-76%	0%	6%
2035	8%	27%	33%	149%	18%	5%	-66%	0%	8%
2040	12%	28%	20%	170%	24%	7%	-65%	0%	12%
2045	13%	23%	-8%	159%	26%	8%	-61%	0%	13%
2050	16%	32%	21%	138%	30%	10%	-50%	-31%	16%

Source: U.S. Energy Information Administration, *International Energy Outlook 2021*

Table 4. Low Coal Supply Case: India and Greater Southeast Asia (GSEA) coal demand and supply

million short tons

India Year	India total demand	Production (+)	Exports (-)	Domestic supply	Imports from Africa (+)	Imports from Australia (+)	Imports from GSEA (+)	Imports from Canada, Russia, and United States (+)	India total supply
2030	1,197	763	--	763	47	246	108	34	1,197
2035	1,377	832	--	832	70	305	89	80	1,377
2040	1,557	915	--	915	106	327	85	124	1,557
2045	1,638	936	--	936	133	342	74	153	1,638
2050	1,850	1,032	--	1,032	147	393	107	171	1,850

GSEA Year	GSEA total demand	Production (+)	Exports to India (-)	Exports to rest of Asia (-)	Domestic supply	Imports from Africa (+)	Imports from Australia (+)	Imports from Canada, Russia, and United States (+)	GSEA total supply
2030	632	662	108	33	521	9	94	8	632
2035	737	718	89	34	595	10	122	9	737
2040	775	736	85	35	616	11	138	10	775
2045	817	743	74	32	636	12	158	11	817
2050	886	817	107	32	678	13	179	16	886

percentage change from Reference case

India Year	India total demand	Production (+)	Exports (-)	Domestic supply	Imports from Africa (+)	Imports from Australia (+)	Imports from GSEA (+)	Imports from Canada, Russia, and United States (+)	India total supply
2030	-8%	-13%	--	-13%	64%	21%	-38%	87%	-8%
2035	-13%	-22%	--	-22%	87%	28%	-57%	213%	-13%
2040	-17%	-29%	--	-29%	61%	33%	-63%	257%	-17%
2045	-24%	-38%	--	-38%	43%	33%	-67%	146%	-24%
2050	-16%	-35%	--	-35%	30%	47%	-37%	137%	-16%

GSEA Year	GSEA total demand	Production (+)	Exports to India (-)	Exports to rest of Asia (-)	Domestic supply	Imports from Africa (+)	Imports from Australia (+)	Imports from Canada, Russia, and United States (+)	GSEA total supply
2030	-2%	-15%	-38%	-10%	-8%	-1%	54%	0%	-2%
2035	0%	-18%	-57%	0%	-7%	0%	48%	0%	0%
2040	-6%	-23%	-63%	0%	-11%	-3%	28%	0%	-6%
2045	-13%	-28%	-67%	-3%	-18%	-8%	15%	0%	-13%
2050	-15%	-22%	-37%	0%	-20%	-9%	11%	-14%	-15%

Source: U.S. Energy Information Administration, *International Energy Outlook 2021*