PROPOSED NEW CAPACITY AND POWER SECTOR DECARBONIZATION:
Implications of Global Coal Power Development for the Paris Agreement

TECHNICAL REPORT

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Ryna Yiyun Cui,[1] Nate Hultman,[2] Haewon McJeon,[1] Linlang He,[2] Arijit Sen,[2] Kavita Surana,[2] Xiayun Tan,[2] Shannon Kennedy[2]

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[1] Joint Global Change Research Institute, Pacific Northwest National Laboratory, College Park MD 20742
[2] Center for Global Sustainability, School of Public Policy, University of Maryland, College Park MD 20742

EXECUTIVE SUMMARY

The Paris Agreement, signed by 195 Parties with broad engagement from businesses, subnational actors, and citizen groups, crystallized the world's commitment to stabilizing and reducing emissions while limiting global temperature increase to well below 2°C above pre-industrial levels, while pursuing efforts to limit the temperature increase even further to 1.5°C.

Achieving these goals will not be possible without a rapid phase-out of existing coal-fired electricity and a dramatic reduction in the construction of new coal power. Moreover, as part of the Paris Agreement, countries advanced national targets, known as nationally determined contributions (NDCs), which identify their roadmaps towards lowering emissions. However, at the same time, many of these countries are still actively planning, authorizing, and constructing new coal-fired power plants, which if actually built would prevent many from reaching their national goals and would make reaching global climate goals nearly unattainable.

This report examines the current trend of global coal power development and how those trajectories will affect these national and global goals. Moreover, this report looks at six key countries – China, India, the United States, Indonesia, Japan, and South Korea – and the potential impact of existing and future coal power facilities on their attainment of NDCs. The key findings include:

- **Coal Power Is Still Growing:** A total of over 860 GW of new coal capacity could potentially be added in the next few years, adding 4.6 GtCO2e greenhouse gas (GHG) emissions in 2030—an increase of nearly 10% from current total global emissions.
- **Reversing Coal Expansion Creates a Window for Reaching Near-Term Paris Goals:** Aggregate NDC targets can potentially be achieved by canceling proposed coal projects at early development stages (i.e. planning or permitting), equivalent to 3.0 GtCO2e of GHG emissions.
- **The Long-Term Goal of "Well-below 2°C" Requires Fundamental Shift away from Coal:** Significant changes are needed to close the emission gap of 9.3 GtCO2e to the 2°C goal in 2030. Limiting warming to well-below 2°C requires not only cancelling ***all*** proposed coal-fired power projects, but countries must accelerate the ***retirement*** of existing capacity.
- **Action Now Would Allow the World to Achieve the Paris Goals with Much Lower Cost:** Coal power infrastructure, once in place, is likely to run more than several decades and lock the world in a carbon-intensive system. Countries must cancel all of their newly proposed coal-fired power projects. Otherwise these projects would have to retire prematurely in the post-2030 period in order to get on track with long-term climate goals.

Stronger policy efforts are needed from all of the key countries for the world to have a chance of hitting the long-term 2°C goal, but development challenges in some countries may prevent them from making decisions that are necessarily climate-friendly. The potential conflict between country-specific development goals and global-level climate commitment calls for not only more coordination among stakeholders within each country, but also more dialogues among decision-makers around the world. It is also important for countries to bear in mind their long-term climate commitment while making their short-term energy investment decisions because only by so doing would give them a chance of achieving the Paris Goals cost-efficiently.

INTRODUCTION

The goals of the Paris Agreement necessitate rapid decarbonization in the power sector, yet global coal power generation capacity has continued to grow in recent years and the rate of increase is not slowing quickly enough.

The Paris Goals and Coal Power

Existing and future coal power infrastructures have important implications for GHG emissions and the climate goals of the Paris Agreement. The Paris Agreement has set a global goal of limiting the average temperature rise to well below 2°C above pre-industrial levels. In the short-term, as part of the Paris process, countries have provided their own commitments and emissions reduction targets in the form of Nationally Determined Contributions (NDCs).[1]

Earlier studies of near- and long-term ambition focused primarily on tracking greenhouse gas emissions only, but recent studies have begun looking at a broader set of sectoral and technological metrics, for example targeting the degree of energy system transformation. It is broadly recognized that emissions cuts well beyond the current NDCs will be necessary to remain below 2°C – approximately 11-13.5 Gt globally according to the UN Gap Report.[2] What's more, to accomplish the subsequent energy system transition, changes must be significantly accelerated from historical and current energy trends.[3] Analyses that look at sectoral and technological details have demonstrated the extent of needed efforts more comprehensively and provide additional information to policy making.

When translating long-term temperature goals to emission pathways and energy system transitions, there are robust findings with respect to coal-based power generation. According to the most recent International Panel on Climate Change (IPCC) report, there are many different emissions trajectories that have more than a 50% chance of keeping the average global temperature rise under 2°C, but almost all of them require a rapid decarbonization of the global power sector.[4] In this context, our findings indicate that all conventional coal power generation capacity that is not equipped with carbon capture and storage (CCS) will need to be phased out roughly within the next 30 years.

A switch from coal power generation is critical in the immediate future for three reasons:

1. To achieve the 2°C goal, only about 1,000 Gt of the global cumulative carbon budget is estimated to be remaining as of 2011.[5] No matter which emission pathway is taken, the cumulative allowable emissions are fixed within a range. Therefore, even with significantly decreased emissions in the second half of the century, the amount we can emit up-front is still limited.
2. Coal power infrastructure, once in place, is likely to run more than several decades and lock the world in a carbon-intensive system. Coal combustion has by far the largest carbon footprint in the power sector, contributing to about 70% of global cumulative carbon emissions from power generation during 1950 to 2012. Additionally, existing coal power generation facilities are committed to 206 Gt more of carbon emissions through their remaining expected lifetime.[6]
3. Decarbonization of the global power sector is often the most cost effective strategy compared to investing in other sectors such as the electric transportation.[7]

This study assesses the ongoing changes in coal power generation capacity and provides an alternative indicator that tracks countries' progress towards their NDCs as the world attempts to stay on a pathway to "well below 2 degrees."

Current Coal Power Development

The most recent development trend shows that global coal power generation capacity has been growing fast in recent years and is expected to continue to grow in many parts of the world. The total installed coal power generation capacity has nearly doubled during the past 10 years and exceeded 2,000 GW in 2015[8], accounting for about one-third of the global total installed power generation capacity.[9] Moreover, there are tremendous amount of new coal power plants currently under development and to be added in many regions of the world. In particular, we find a potential total of more than 860 GW of new capacity coming online in the next 15 years, including 233 GW that have already started construction.[10]

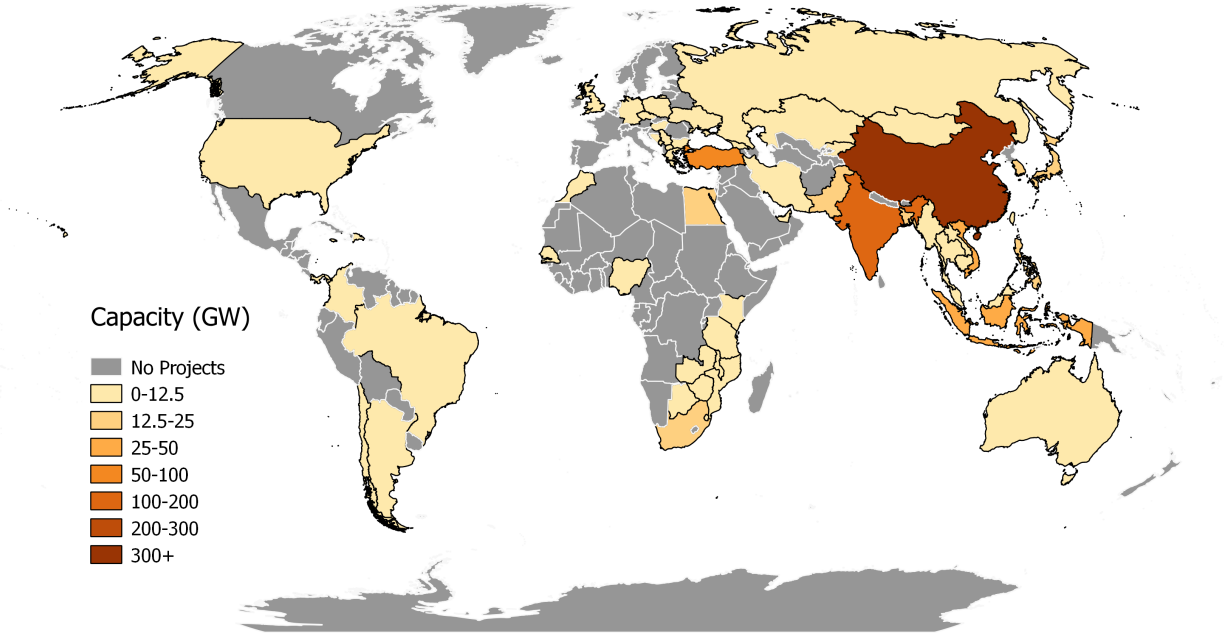


Figure 1. Newly Proposed Coal-fired Power Capacity by Country

Our data is based on unit-level assessments of newly proposed coal power plants worldwide. We collect information of each unit regarding the proposed capacity, combustion technology, local air pollutant control, sub-national location, developers, project utilization, and so forth. Development status of all proposed units are updated as of September 2017. We use various data sources, including governmental development plans, coal industry status reports, energy market regulatory reports, environmental impact assessment reports, company websites, and a variety of news channels.

In the context of power sector decarbonization, coal capacity that is planned or in progress but not yet complete is of particular interest because changing course for these cases is easier than for existing plants. More than 60 countries have plans to add new coal-fired power capacity, but measured by total capacity, the vast majority of the planned activity is located in Asia. Five countries alone – China, India, Turkey, Vietnam,

and Indonesia – account for about three quarters of the newly proposed capacity (Figure 1 and Figure A1 in the appendix). Turkey and Vietnam are looking for a five- and four-fold increase in coal power capacity, respectively. Indonesia is planning to more than double their current coal operations. This reflects a recent geographic shift in coal power prioritization from OECD countries to many fast developing countries in Asia (Figure A2 in the appendix).

Proposed new additions of coal-fired power generation capacity are at different stages of development. We track the proposed new coal power capacity at its different stages of project development. Globally, about 27% already started construction, more than 10% have been authorized by their government, about 40% are going through the permitting process, and the remaining 23% are at very early planning stage (Figure 2). The later phase the proposed projects are, the higher is the chance they will be actually implemented.

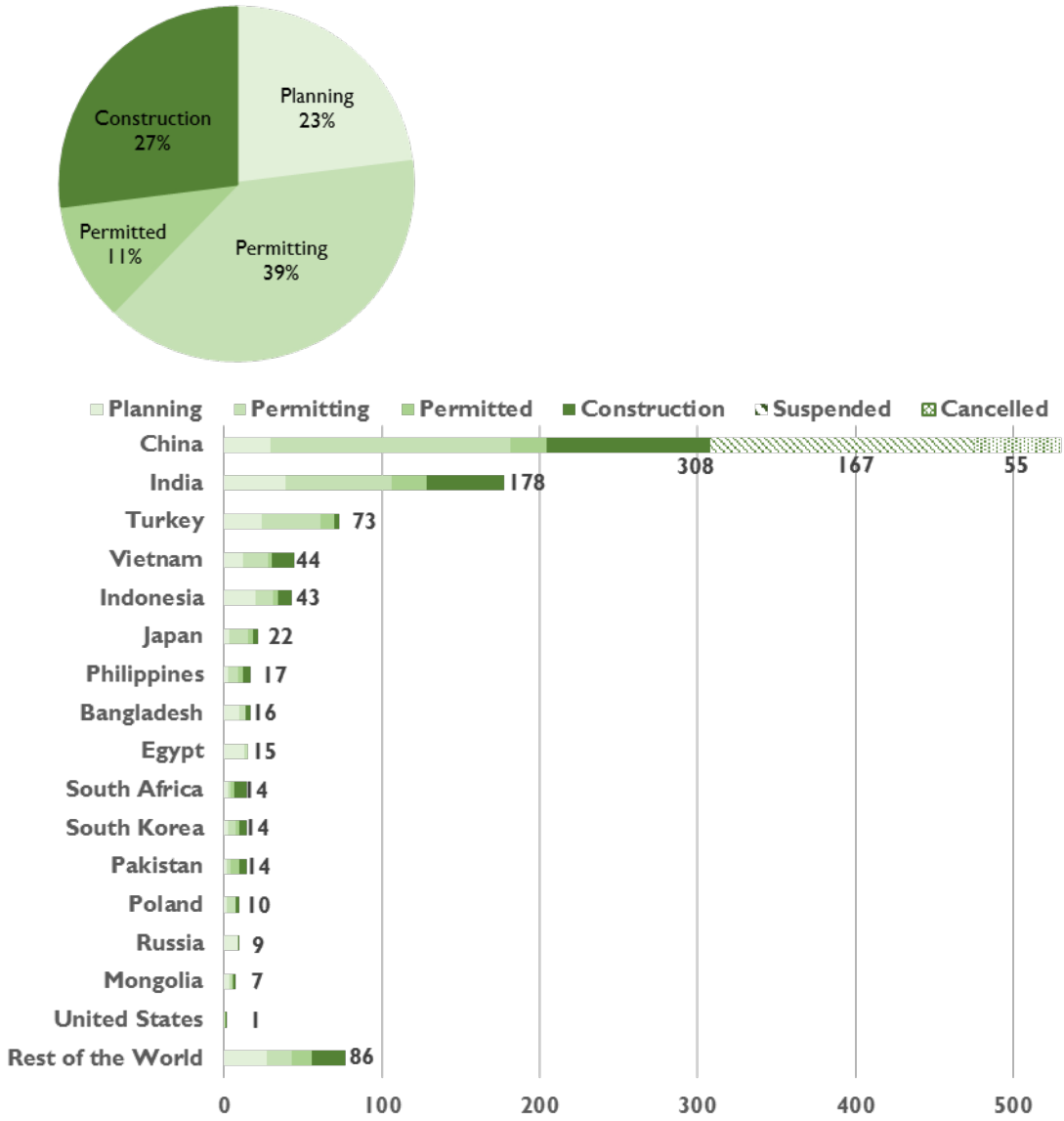


Figure 2. Newly Proposed Coal-fired Power Capacity by Development Stage, Global and by Top Country

The Chinese central government has imposed a series of restrictive policies on coal power development since 2016. China saw a period of rapid expansion over the past 15 years including the construction of the majority of their power plants.[11] However, since 2016, the Chinese central government has imposed a series of restrictive policies under which a total of 222 GW proposed coal power projects have been cancelled or suspended.[12,13,14] Despite this significant cutback, China continues to develop 308 GW of new capacity, a capacity that itself is still much greater compared to other countries (Figure 2).

Our data shows similar coal power development trends and geographic distribution as other databases that track the status of coal power projects at the unit level, most notably the Global Coal Plant Tracker.[15] In general, we have higher estimates of the proposed capacity both globally and for several key coal power developing countries.[16] There are several potential reasons for such differences. We believe the majority of the disparities come from different definitions used to categorize the proposed projects. For example, the Global Coal Plant Tracker defines a project that shows no activity over a period of 2 years as "shelved". In contrast, we categorize projects based on the most recent information available, unless there is explicit evidence indicating that the project has been suspended or cancelled. This was seen in places like China where more restrictive policies are present. In addition, some projects may have changed their status between September 2017 and January 2018, and the different stopping points of our data collection process could account for a small portion of the differences.

Because of an expected reluctance of project developers to phase out newly built capital investments before their useful lifetime has ended, this new coal power infrastructure planned for completion in the next decade would significantly reduce the likelihood of phasing out all coal power generation capacity by mid-century. Therefore, this report addresses three linked questions:

1. How does the current trend of coal power development deviate from the trajectories that are consistent with meeting the Paris climate goals?
2. If all these proposed projects are implemented, what is the impact on GHG emissions?
3. Are individual countries on track to complete the goals of their NDCs as well as contribute to the global goal of keeping temperatures well below 2°C?

GLOBAL ASSESSMENTS

Our analysis indicates that globally, the aggregate NDC targets for 2030, due to less ambitious targets, can be met by canceling a portion of proposed projects at their early stages, but reaching the 2°C goal will require far more significant action.

Coal Power under Three Scenarios

We assess and compare GHG emissions from conventional coal power generation across three scenarios – the continued coal growth scenario, the Paris-NDC-continued-ambition scenario and the well-below 2°C scenario. We use the Global Change Assessment Model (GCAM) version 4.3[17] to run all three scenarios.

GCAM is an integrated human-earth system model that represents and links the world economy, energy, agriculture and land-use, water, and climate systems. It is designed to explore interactions between complex systems and gain insights about long-term trends. GCAM has been used widely to produce scenarios for international and national assessments, including the Intergovernmental Panel on Climate Change (IPCC)

reports, the Representative Concentration Pathways (RCPs)[18] and the Shared Socioeconomic Pathways (SSPs).[19]

Specifically, GCAM takes in assumptions about population growth and changes in labor productivity, along with representations of resources, technologies and policies, and runs in 5-year time steps from 2010 (calibration year) to 2100 by solving for the equilibrium prices and quantities of various energy, agricultural and GHG markets in each time period at different spatial resolution. GCAM tracks the emissions of sixteen GHGs, aerosols, and short-lived species endogenously based on the resulting energy, agriculture, and land systems. Emissions are then passed to the climate carbon-cycle module and converted to concentrations, radiative forcing, temperature, and other responses to the climate system.[20] In GCAM4.3, the world economy and energy systems operate across 32 geo-political regions, and land allocation and agricultural production are modeled across 283 land regions. Primary energy (coal and other fossil fuels), agricultural products, and biomass are traded globally, while secondary energy (electricity) is traded regionally.

Energy demand trajectories in all three scenarios are based on the same socioeconomic pathway that is in line with the middle-of-the-road scenario of SSP2.[21] However, as coal generation projections, emission, or temperature targets are implemented in different scenarios, we would get very different fuel mix in energy supply as well as the associated GHG emissions from power generation.

- **The Continued Coal Growth scenario** assumes power generation from conventional coal technology will follow the current national trends, while all other sectors follow the reference scenario without additional emission reduction efforts. Historical coal power generation up to 2010 is calibrated in standard GCAM. For additional construction until 2015, we used the latest capacity data available (see country information boxes in the next chapter). After 2015, we simulate all of the proposed capacity that will be deployed over the next 15 years, based on unit-level data of the proposed coal power capacity (see country summary statistics in Table A1 in the appendix). Specifically, all the capacity currently under construction is assumed to come online by 2020; all the capacity that is permitted or still in permitting process is assumed to come online by 2025; and all the planning capacity (including the suspended projects in China), is expected to come online by 2030. The coal plant growth rate between 2010 and 2030 is assumed to continue until 2050 then remain consistent. All the newly built coal plants are assumed to retire after operating through a lifetime of 50 years. Coal power generation valued by region is calculated by applying region-specific capacity factors from the U.S. Energy Information Administration.[22]

- **The Paris-NDC-Continued-Ambition scenario** interprets and translates all the individual country's commitments under the Paris Agreement as total national emission constraints by 2030. It is based on the same scenario developed in Fawcett et al. (2015)[23], First, it assumes that countries meet their (I)NDC goals by 2030; second, it assumes that countries continue to decarbonize their economies beyond 2030, with the same annual decarbonization rate – reduction in carbon intensity per GDP – between 2020 and 2030, with a minimum decarbonization rate of 2% per year is chosen beyond 2030, should the actual (I)NDC decarbonization rate be smaller than that.

- **The Well-Below 2°C scenario** limits the global mean temperature change to well-below 2°C without overshooting the temperature target throughout the century. This results in temperature increase peaking at 2.0°C around 2055, and by 2100, temperature increase is approximately 1.6°C.

Emission reductions are implemented cost-effectively across regions and sectors at a universal global carbon price on energy-related emissions. This is different from the regionally differentiated approach used for the Paris-NDC-Continued-Ambition. The use of bioenergy is constrained to a maximum of 200 EJ globally over the simulation period. This limits the maximum level of negative emissions from bioenergy plus carbon capture and storage (BECCS) to -11 GtCO2 by 2100. This bioenergy constraint can avoid potentially unrealistic large-scale deployment of negative emissions technologies[24]. BECCS in particular, during the second half of the century, but at the same time, induces more aggressive emission reductions in the near-term.

Global total GHG emissions under the three scenarios are shown in Figure A1 in the appendix.

Global Aggregate Goals

Under the continued coal growth scenario, coal-fired power generation in 2030 would result in 12.5 GtCO2e of GHG emissions globally, of which 4.6 GtCO2e would come from new capacity that is currently being proposed.

Moreover, because of its long lifetime, coal power generation infrastructure, once in place, is likely to continue generating emissions over several decades. Translating the annual GHG emissions (Figure 3) to cumulative emissions (Figure 4), existing and currently proposed coal power projects would result in a total of 575 GtCO2e GHG emissions by 2080.

Compared to the Paris-NDC-Continued-Ambition scenario, emissions from existing and proposed coal power capacity are not consistent with the trajectory to attain the aggregate NDC goals by 2030, with an emission gap of 2.5 GtCO2e GHGs in 2030 (Figure 3). To close the emission gap, canceling all projects at the early planning and permitting stages would reduce 3.0 GtCO2e of GHG emissions and would bring the trajectory consistent with the aggregate NDCs.

On the other hand, the proposed coal power capacity is not at all consistent with the well-below 2°C scenario. The emission gap for the 2 degree scenario is 9.3 GtCO2e in 2030 (Figure 3). In fact, meeting 2°C goal requires not building any new coal plants, as well as an accelerated retirement of existing coal plants.

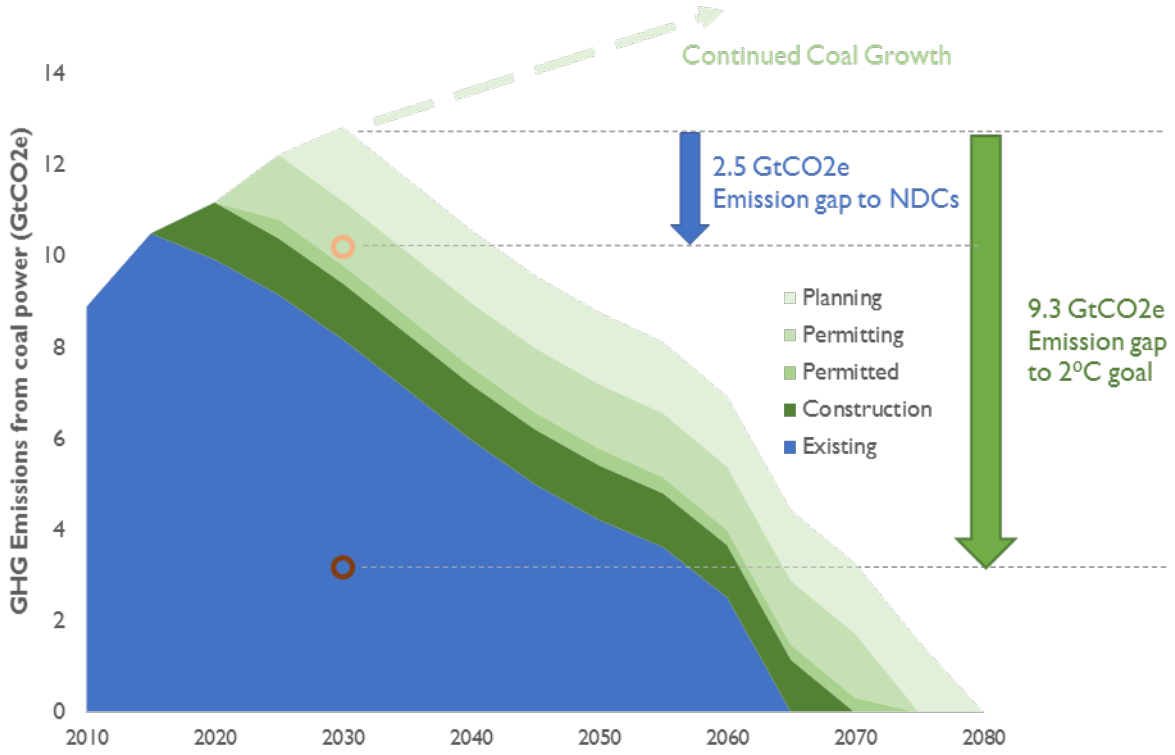


Figure 3. Global Greenhouse Gas Emissions from Coal Power Generation, 2010-2080

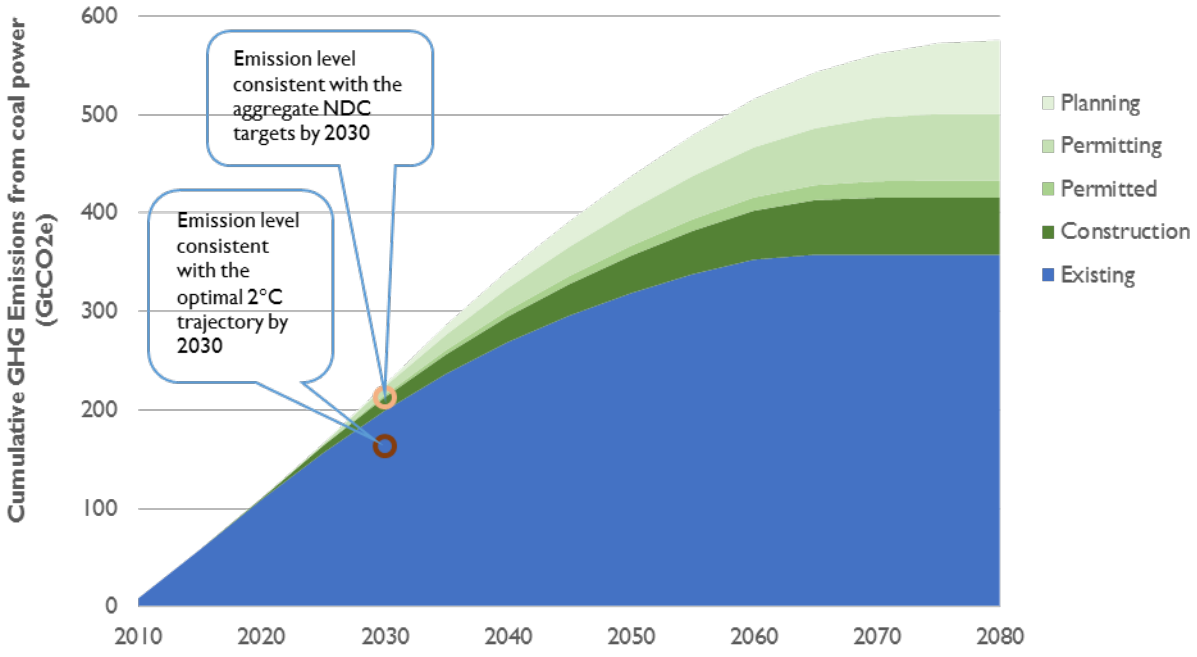


Figure 4. Cumulative GHG emissions from coal power generation, 2010-2080

While meeting NDC targets only requires minor changes in proposed coal projects, meeting the global long-term goal of "well-below 2 degree" requires a fundamental shift away from coal. This discrepancy is primarily because the NDC targets, in aggregate, fall short of being on track to 2°C.[25] The (less ambitious) NDC targets can nominally be achieved by canceling a portion of proposed coal projects at early development stages (i.e. planning or permitting) with expected retirement of older capacity. However, meeting the 2°C goal requires the cancellation of **all** new additions of coal-fired power generation capacity, including those that already started construction, in addition to the accelerated **retirement** of existing capacity (Figure 5). Otherwise, any new additions would subsequently have to retire prematurely in the post-2030 period to get back on track with the long-term global goal.

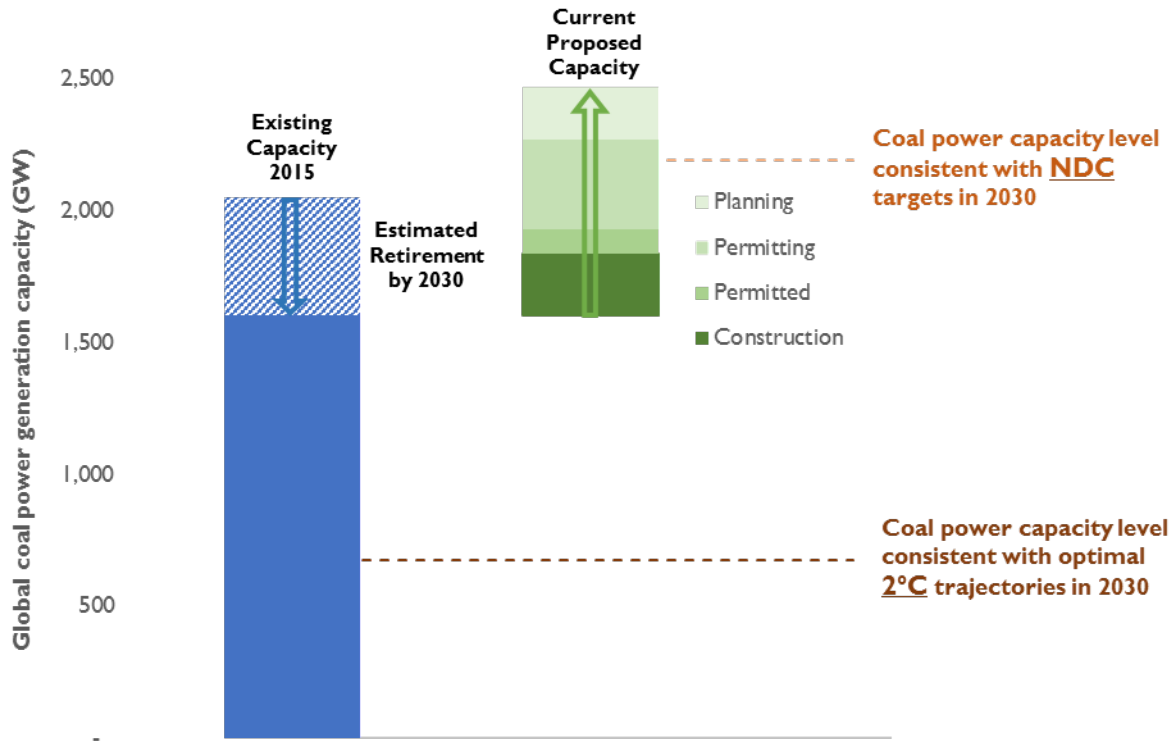


Figure 5. Global Coal Power Generation Capacity in 2030

Our findings are broadly consistent with results from other studies indicating the urgency of rapid action on reducing coal utilization. We compare our results with three other studies the recent and continuing global coal power expansion is not in line with long-term climate goals. Table 1 summarizes conventional coal power generation and the associated GHG emissions under alternative scenarios.

With respect to the scenarios that reflect current market trends – equivalent to our continued coal growth scenario, all of the three studies depend on data from different versions of the Global Coal Plant Tracker database[26]. Our data show comparable global and national trends in terms of proposed new capacity, and the resulted generation and emission projections in 2030 are also generally in line with the other studies. With respect to the 2°C trajectories, there are great uncertainties in the near-term, and the range of coal power generation in 2030 from a suite of the 2°C scenario is large.[27] Our coal power generation number in 2030 is around the median value within that range. The 2030 emissions compared with the other two studies shows

our number around the middle but towards the lower end. As we discussed above, we use a well-below 2°C scenario with a bioenergy ceiling, which tends to require more emission reductions in the near-term compared to the alternatives.

Table 1. Comparison of global coal power generation and emissions in 2030 with literature

Study	Continued-Coal Scenario		2°C scenario	
	Coal power Generation	Coal power Emission	Coal power Generation	Coal power Emission
This report	46.6 EJ	12.5 GtCO2e	11.9 EJ	3.2 GtCO2e
van Breevoort et al. (2015) [28]	45 EJ*	11 GtCO2e*	5-30 EJ	-
Rocha et al. (2016) [29]	-	13 GtCO2e*	-	2.5 GtCO2e
Edenhofer et al. (2018) [30]	-	13 GtCO2e*	-	7.5 GtCO2e*

* Estimated by authors

It is worth noting that several assumptions in our analysis could potentially influence the results in terms of coal power generation as well as the associated GHG emission trajectories, however, they do **not** change the insights we learn.

First, we assume all of the newly proposed projects will be implemented by 2030. This is unlikely to happen, especially in countries like India that has a low project implementation rate[31] due to various regulatory, financial, and other project management obstacles.[32]

Second, we employ region-specific capacity factors based on recent history when estimating future coal power generation from new capacity. This may overestimate future generation and the associated GHG emissions for some countries, while underestimate those numbers for others. For example, China is already facing major issues with excess power generation capacity due to flat demand, and the average capacity factor of coal power has been declining in recent years (See more discussions about China in the Chapter of Country-Specific Assessments). Therefore, it is likely to observe declining utilization rates of coal power as more capacity is added in China. On the other hand, however, new projects are expected to be more efficient with better technologies than existing ones, and thus replacing old infrastructure with new builds tends to increase the average capacity factor for certain countries.

Third, we have generally higher estimates of proposed coal-fired power capacity compared to another database.[33] As discussed earlier, the majority of the disparities are caused by different data collection methods. Our data collection and analyses include as many potential projects as we can find, unless there is explicit evidence indicating the opposite.

Although there are uncertainties around the assumptions we made, they do not affect our main conclusion that any new addition of coal capacity is not consistent with the 2°C goal.

Cross-Country Comparison

China, India, Indonesia, the United States, Japan and South Korea, collectively account for 78 percent of global total existing coal power generation capacity and 66 percent of the proposed capacity as of 2017.[34]

Although the magnitude and age of coal power infrastructure vary substantially in 2030 across these countries, with the estimated rate of retirement, most countries have some room for new additions and can still achieve their NDC targets. However, to remain consistent with the 2°C goal, all new projects would be cancelled in addition to the accelerated retirement of existing capacity (Figure 6).

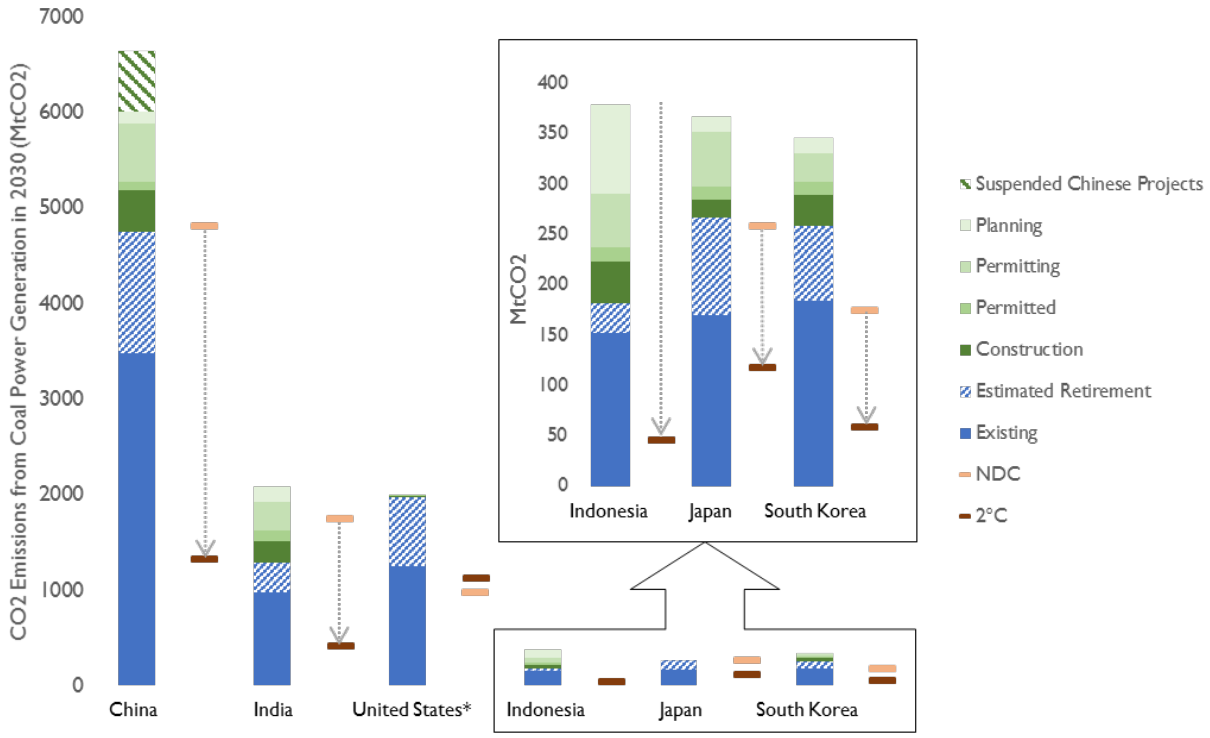


Figure 6. CO2 Emissions from Coal Power Generation in 2030
Note: *2025 emissions are shown for the United States

China, despite its recent cancellations of some proposed new capacity, runs a real risk of missing its NDC target in 2030 under current coal power development plans. While estimates[35] show that China's emissions may have already peaked in 2015 – one decade and half earlier than its NDC target – in addition to reduction of GDP intensity by 60-65% from 2025 level[36], there are significant uncertainties after 2020. Having said that, uncertainties exist post-2020. It will stay on track with its NDC target by cancelling the 167 GW of projects on hold until after 2020, and by retiring existing capacity with the estimated rate or by cancelling projects that are currently under active development. As for staying in line with the 2°C scenario, however, any new builds after 2010 would deviate from the least-cost pathway, and retirement of existing capacity would need to occur at much faster speed.

India has committed in its NDC to reducing their emissions intensity of its GDP by 33 to 35% by 2030 from 2005 level.[37] In the power sector, the commitment is to achieve 40% non-fossil fuel power capacity by 2030, increase from 32% in 2016.[38] India accounts for about 20 percent of the newly proposed coal power capacities globally, but the realized expansion may be much lower. By canceling some proposed projects that are at very early stages or following the expected retirement of existing facilities, India is on track to achieve the NDC target for 2030, but these efforts will not allow India to stay in line with its 2°C trajectory.

Indonesia's NDC targets include a 29% GHG reduction below business-as-usual (BAU) by 2030, or a 41% conditional on international aid.[39] Even with a large coal expansion plan, including significant infrastructure development, Indonesia is likely to be able to reach its NDC goal because of high BAU projections and less ambitious mitigation targets. However, in comparison to other country's NDCs, Indonesia is not on track to reach the least-cost 2°C goal on their current trajectory.

The United States can achieve a trajectory toward the 2°C goal with a moderate amount of additional retirement. But more of an effort is needed to achieve their NDC goal of a 26-28% GHG reduction below 2005 levels by 2025.[40] United States, like most other OECD countries such as the European Union, Australia and Canada, has little ongoing new coal power development, but would still need to retire a large amount of the existing capacity to meet the NDC.

Japan and South Korea are the only OECD countries that have a considerable amount of new conventional coal power capacity actively under development, and neither is on track of achieving its NDC targets without significant action to curtail this proposed capacity. Japan's NDC targets a reduction of 26% from 2013 levels by 2030[41] and we estimate this is only achievable if they retire their existing fleet or cancel proposed projects that are at early stages. Reaching a 2°C trajectory is even harder because Japan would need to combine both retirement and cancelation at an even faster phase-out schedule. South Korea has little room for any new coal power development if they want to reach both their NDC goal of 37% less emissions than BAU by 2030[42] or a 2°C trajectory. None of their proposed projects are consistent with a trajectory to deliver the NDC, and a much faster retirement schedule is necessary to get on track with the 2°C goal.

COUNTRY-SPECIFIC ASSESSMENTS

CHINA

The Chinese central government's strong interest in reducing coal power overcapacity and rising public awareness of pollution-related health issues have the potential to steer China away from future coal power development, but whether coal power's dominant share in China's existing power mix can change in the next decade remains the subject of much uncertainty. On the one hand, China has challenges in incorporating its variable renewable energy into its somewhat rigid grid system. On the other hand, the perpetual "push-and-pull" between environmental goals and other development objectives, and the potential mergers between the coal and power industries could shield the coal-fired power plants from unfavorable market conditions and signals that would otherwise have shut them down.

The central government has a strong will to address the problem of coal power overcapacity

China's coal power industry is facing major issues with excess capacity. The average capacity factor of coal power was 47 percent in the end of 2016, the lowest since 1964.[43] This overcapacity issue is partially caused by a policy change in 2014, which granted the provincial governments the authority to approve coal power plant proposal[44], and partially due to many Chinese localities' heavy reliance on carbon-intensive economic activities for their revenue stream. In response to this, since 2016, the Chinese central government has imposed a series of restrictive policies under which a total of 222 GW proposed coal power projects have been cancelled or suspended.[45,46,47]

In addition to restrictive policies, in May 2017, China's National Energy Administration also released a report evaluating the different provinces' coal power development plan for the Year 2020.[48] This report created a composite indicator measuring the economic feasibility, degree of overcapacity, and resource burden associated with the provincial coal power development plans. According to this report, only two provinces (Hunan and Hainan Province) have a "green" overall risk indicator, so it aims to send a signal to local governments that due to their high risks, most of them should reconsider their proposed coal power development plans.

Concerns from the general public about the health impact of air pollution have spurred an improvement in air pollution control

Severe air pollution is among the most difficult policy challenges faced by China. According to a recent study, which monitored the daily average air quality of 190 cities in China for the entire year of 2013, only 25 of these cities were able to meet China's National Ambient Air Quality Standard.[49] China's national standard for PM2.5, one of the most hazardous local air pollutants, is a daily average concentration of 75 micrograms per cubic meter and an annual average concentration of 35 micrograms per cubic meter.[50] This is far higher than the WHO's suggested values[51], and indicates that the actual scale of China's air pollution problem may be even higher than what this study suggests.

Facing increasing complaints about the hazardous air quality from its citizens[52], the central government urged the public to be "patient" when it came to improving air quality[53], but also took this battle head-on and worked diligently to come up with potential remedies, including measures that have direct impacts on coal-fired power plants. For example, since the 12th Five-Year-Plan, "desulfurization equipment is required to be installed in all coal-fired machinery; and denitrification equipment is required for coal-fired power plants with

capacity of 300,000 kilowatts or more nationwide."[54] Also, effective January 1st 2015, China started to ban lignite if it contains 30 percent or more of ash content and 1.5 percent or more of sulfur content. Additionally, China no longer allowed sales or the import of "other coal" if it contains 40 percent or more of ash content and 3 percent or more of sulfur content.[55] Meantime, the Ministry of Environmental Protection has been working on improving its monitoring and supervision capacity. From 2016 to 2017, the Ministry of Environmental Protection, in total, dispatched around 40 teams to the different provinces in China, conducting a one-month review of local environmental management efforts.[56] They deliberately make their presence visible to the general public, invite the citizens to send in their complaints and concerns, and hold local officials accountable for resolving these issues. If these kind of spot-checks become the new "norm" in the coming years, as claimed by the central government, the general public's concerns about air pollutions' health impacts may continue to spur improved environmental management effort at the local level in the near future.

Coal will maintain its dominant share in China's energy mix in the near future

China's natural gas market has grown in the past decade and is expected to keep growing given its low prices, ample supply, and smaller impact on air pollution and emissions[57], but it has problems of its own. Even though China recently became the world's fourth-largest gas producer[58], and plans to use natural gas for 10 percent of its energy consumption by 2020[59], China faces many challenging geological issues regarding its domestic gas exploration and production[60]. What's more, the Chinese government's reliance on steady economic growth and standard of living improvement for its legitimacy has impeded the transition from the cheap-and-abundant coal to natural gas.[61]

It is unrealistic to think that renewable energy will be able to challenge coal's dominant share in China's energy mix in the near to medium term. Even though China has been the world's leader in renewable energy development in recent years[62], the share of renewables in the country's power generation mix is still quite low – estimated to be around 6.3 percent as of 2016.[63] This relatively low market penetration rate is partly due to China's major challenge in incorporating its variable renewable energy into its somewhat rigid grid system.[64] According to a recent Bloomberg study, "China's national average curtailment rate for wind and solar were as high as 17% and 19.8% in 2016".[65]

China depends on the heavy-polluting "pillar industry" while local policy implementation efforts are weak

With high rates of poverty lingering in many parts of the country, China faces the perpetual "push-and-pull" between environmental goals and other development objectives, and hence ends up continuing to subsidize its heavily-polluting "pillar industries" in many instances.[66]

To complicate this problem, local governments and officials are sometimes barriers to effective environmental policy implementation at the local level, due to the absence of a proper incentive structure.[67] First, the quality of environmental management has not been included in local performance evaluation metrics until quite recently, and hence was not viewed as something that would provide rewards for political future advancement.[68] Second, in China's overall governance structure, the local environmental bureaus appear to be "subordinates" of the provincial and local governments because they are administratively supervised and financially supported by them.[69] Such dependent relationships make it almost impossible for

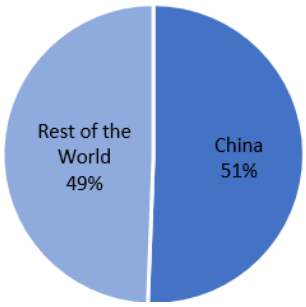
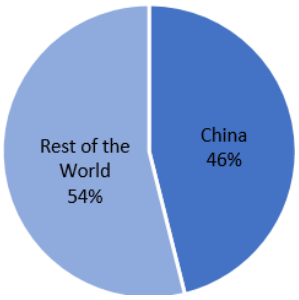
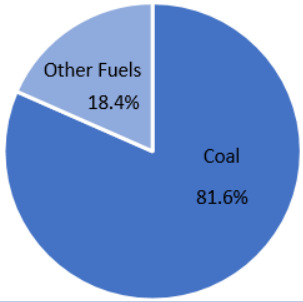
the local environmental bureaus to disrespect the guidance from the provincial and local governments, who may have chosen to turn a blind eye to the heavy polluters in their jurisdiction in exchange for faster economic growth, more employment opportunities, or more stable tax revenue.

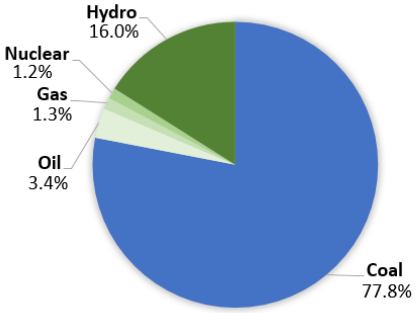
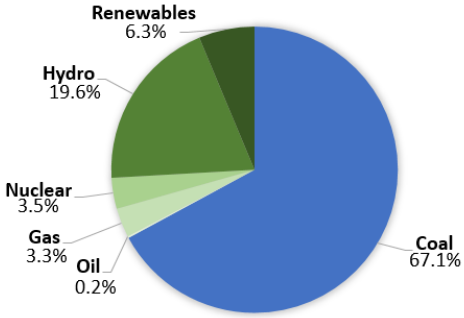
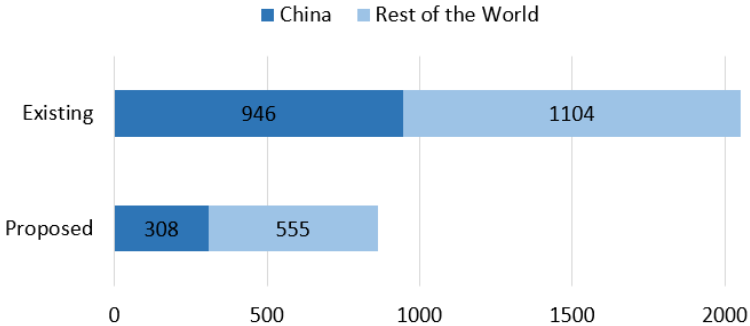
China's rigid system is coupled with unfavorable market trends

China has a relatively rigid power structure and grid operation system. Unlike the flexible U.S. system where spot markets allow grid companies to purchase electricity from different sources from time to time[70], China's two state-owned grid companies sign annual contracts to purchase electricity from all operating coal-fired plants.[71,72] These long-term purchasing contracts cannot be abandoned easily, and to a certain extent prohibits existing coal-fired plants from shutting down in the short term. In fact, In April 2017, the National Development and Reform Commission (NDRC) ordered coal companies and utilities to fix 75 percent of their total coal purchases through long-term contracts, up from the current 60 percent[73], because most listed losses of Chinese power companies in the first half of 2017.[74] Such actions would give existing coal power plants even less incentives to shut down.

Meanwhile, China's coal and power industries are expected to see more mergers in the near future, due to some state-owned enterprise reform policies that were announced in early 2017.[75,76] To Chinese leaders, these reforms are particularly important when thermal coal prices are high and volatile[77], but the flip side of this is that these potential mergers could shield the coal-fired power plants from unfavorable market conditions and signals that would have otherwise shut them down.

Information box – China

Coal consumption (2016)	Coal production (2016)	Energy system CO_2 emissions (2016)
1887.6 Mtoe	1685.7 Mtoe	9040.7 $MtCO_2$
World rank 1	World rank 1	World rank 1
		

Electricity generation by fuel	2000	2016
		
Existing and proposed coal power generation capacity (MW)		

Data Sources:

Coal production and coal consumption numbers are taken from **BP Statistical Review of World Energy June 2017**
Energy system CO2 emissions are taken from **CO2 emissions from fuel combustion, IEA, 2017**
Information on electricity generation mix for Year 2000 is from **Energy Balances of Non-OECD Countries (IEA, 2015)**
Information on electricity generation mix for Year 2016 is from the World Energy Balances (IEA, 2017)
Existing coal power generation capacity is from **China Electricity Council's 2017 Annual Report on China's Electric Power Industry**. Proposed coal power generation capacity is from GCAPD own analysis

INDIA

India's expanding coal use in the power sector matches its growing energy demand and need to provide services and access in a quickly developing country. With expected expansion in population, rapid urbanization, and economic development, a continued increase in energy demand is expected in the next decades. Although coal will continue to power the country in the near-term, recent decline in solar and wind prices put a significant competitive pressure on coal-fired power. Furthermore, India's global climate commitments coupled with domestic concerns over worsening air pollution and environmental degradation may deter increased coal use.

Coal use increases to meet India's growing energy demand

India considers coal to be the backbone of its power sector and future energy mix, and in line with this was the world's second largest coal consumer in 2015. This is particularly notable in the electric power generation sector, which consumed 60% of total coal power in India also in 2015.[78] However, as the world's fourth largest coal producer, domestic coal production does not meet demand. India produced 692 million tons of coal in 2016, and imported over 200 million tons of coal, mainly from Indonesia, Australia and South Africa.[79]

India's enormous and growing energy demand shapes the country's current and future use of coal. The country's current per capita energy demand is well below world average while nearly 240 million people lack access to electricity, as they remain disconnected from the grid. With expected population expansion, urbanization, and economic growth that are estimated to increase energy demand by 5% per year until 2040[80], India's energy policies aim to facilitate the large-scale development of electricity generation capacity through diverse sources, strengthen energy infrastructure, and improve energy access.[81]

The Indian government considers coal an essential part of its energy mix, which currently powers over 72% of India's generation. Given growth in demand, coal capacity is set to increase in absolute terms. However, India's National Electricity Plan estimates that besides the 50 GW of supercritical coal power plants already under construction, no new coal power will be required in the country until 2027[82]. In contrast, the Plan projects renewable capacity additions of 232 GW by 2027.

Coal faces competitive challenges

Cost competition from renewable energy challenges coal power's dominance while driving investment in large utility-scale renewable power plants.[83] In 2017, the average cost of coal power at larger power plants was 5 cents per kWh[84]. At that time India achieved record low prices for solar and wind at about 3.8 cents per kWh.[85]

Coal will continue to face increased costs and risks. Stricter environmental regulations, land acquisition expenses, water stress, high maintenance costs of older plants, and a reliance of import for higher quality coal are expected to increase.[86,87] Furthermore, the coal sector has a history of corruption and oligopolistic behavior in the mining sector, which can create artificial coal shortages and obstruct the competitive use of coal.[88] For example, the coal-rich regions of Eastern India have experienced widespread corruption related to illegal mining, siphoning off coal during transportation, irregularities in allocation of mining permits, financial irregularities, and intersections with organized crime. These issues compound existing costs and risks and negatively impact operation of coal power plants and the broader power system.

Additional obstacles faced by coal power plants make investment in coal increasingly unattractive and bring uncertainty to the construction of new power plants. Existing power plants deal with low load factors, power purchaser payment issues from utilities under debt, and ageing infrastructure. New power plants face various procedural and bureaucratic hurdles. Although power generation is a delicensed activity under the Electricity Act 2003, a coal-fired power plant developer is required to obtain more than 60 permits on coal supply plan, coal transport plan, land acquisition, and environmental quality standards from various central and state government institutions, and in some cases, local government as well.[89] Consequently, many planned coal plants remain in the early building stages as they get suspended or are cancelled due to financial, regulatory, or coal linkage issues before they reach the construction stage.

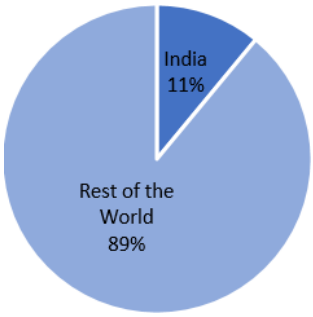
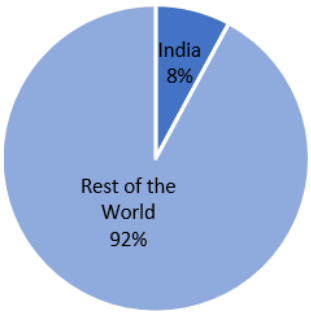
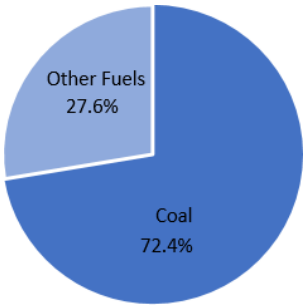
Continued coal use exacerbates public health and environmental concerns

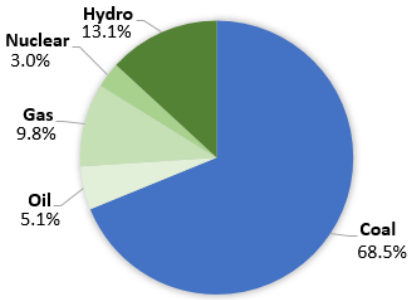
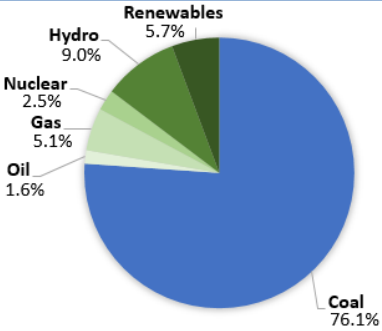
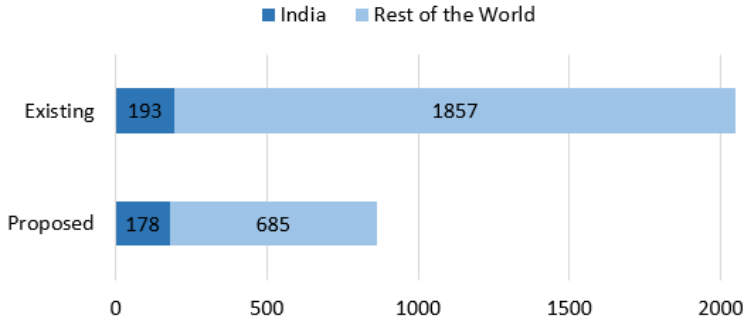
India's cities are already among the most polluted in the world. The economic cost of the health impacts from outdoor air pollution caused by the burning of fossil fuels is estimated to be 3% of India's GDP.[90] As coal use expands, the impacts on public health and broader environmental issues are set to worsen.

The government has engaged in several measures to address rapidly worsening air pollution. While the government has specifically initiated action to curb pollution from coal use, these regulations have not yet been enforced. The Ministry of Environment, Forest and Climate Change (MoEFCC) announced in 2015 its plans to enforce aggressive standards for PM, SO_2, and NOx emissions for existing and new coal plants by December 2017. The government has now asked for five additional years to comply with these rules.[91]

Local communities and environmental groups have focused on the environmental impacts of coal use. Local communities displaced by mining activities and affected by its impacts on forests and livelihoods continue to actively oppose coal mining, while environmental groups such as the Legal Initiative for Forest and Environment argue for stricter adherence to forest regulations in opposition of coal expansion.[92,93] Growing domestic concerns and action related to worsening air pollution and environmental degradation provide opportunities to limit coal use.

Information box – India

Coal consumption (2016)	Coal production (2016)	Energy system CO_2 emissions (2016)
411.9 Mtoe	288.5 Mtoe	2066.0 $MtCO_2$
World Rank 2	World Rank 4	World Rank 3
		

Electricity generation by fuel	2000	2016
		
Existing and proposed coal power generation capacity (MW)		

Data Sources:

Coal production and coal consumption numbers are taken from **BP Statistical Review of World Energy June 2017**

Energy system CO2 emissions are taken from **CO2 emissions from fuel combustion, IEA, 2017**

Information on electricity generation mix for Year 2000 is from **Energy Balances of Non-OECD Countries (IEA, 2015)**

Information on electricity generation mix for Year 2016 is from the World Energy Balances (IEA, 2017)

Existing coal power generation capacity is from **Governmet of India Ministry of Power - Central Electricity Authority Monthly Report, 2017**. Proposed coal power generation capacity is from GCAPD own analysis

INDONESIA

Coal mining and exports are currently a major part of the Indonesian economy. However, the coal economy in Indonesia is changing. Indonesian coal exports are vulnerable to fluctuations in demand from China, India, and global market conditions. Coupled with growing domestic electricity demand, this is driving a shift in the coal economy from exports to the use of domestic coal-fired power plants. These plants are not subject to stringent emission standards and add to the severe air quality issues originating from forest fires. Indonesia's energy policies favor coal, but the expansion in coal use is deeply misaligned with the country's climate targets as well as its environmental and public health issues.

Coal is an important part of the Indonesian economy

Coal has historically played an important role in Indonesia's economy because of its significance in mining and exports. Coal mining contributes to about 5% of the country's GDP and to over 80% revenue from the mining sector.[94] Indonesian coal is mined primarily in three regions—South Sumatra, South Kalimantan and East Kalimantan—with smaller operations in the rest of the country.

Indonesia is one of the world's largest steam coal exporters and an important regional player. Coal exports contribute to 12% of all export income in Indonesia.[95] Indonesian coal that is of medium- and low-quality is competitively priced and is in high demand from large Asian economies. This includes countries like China, Japan, India, and South Korea with high coal-fired power capacity as well as countries like Vietnam, Thailand, and Philippines that are building coal-power plants anticipating use of Indonesian coal.[96] The region's demand for Indonesian coal resulted in the export of nearly 80% of coal produced in 2016.[97]

The coal industry is vulnerable to uncertainty in international markets

The future of Indonesia's coal mining and export industry is subject to substantial uncertainty. Indonesian coal exports are vulnerable to fluctuations in demand from China and India and to the volatility of international market conditions. Coal exports showed a declining trend between 2013 and mid-2016, with a drop of over 20% from 2013 levels, and only a brief recovery in late-2016.[98] The decline in exports was due to shrinking coal use in China, lower import demand from India, and a general slowdown in economic activity.[99] Indonesian coal will continue to face uncertainty from international demand as countries become increasingly hesitant to buy low-quality Indonesian coal under concerns over limiting their GHG emissions.

Domestic demand for coal in power generation is increasing

Coal use is increasing within Indonesia to meet the electricity demands of a growing economy. The electricity demand growth is projected to be around 8.4% per year in the next decade. This reflects expected annual GDP growth of about 5% until 2021, increases in middle class population, rising income per capita, and plans to significantly improve electrification rate from 91% in 2016.[100] Anticipating future demand, the government announced an ambitious electricity infrastructure plan with additional total power generation capacity of 35 GW by 2019, of which 60% would be from coal-fired power plants. This makes coal-fired power the favored choice in meeting Indonesia's domestic power sector ambitions.

The potential role of coal in answering local demand coupled with the volatility in international export markets has resulted in a trend away from coal exports. Domestic demand for coal increased by 40% from

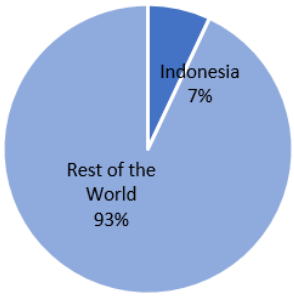
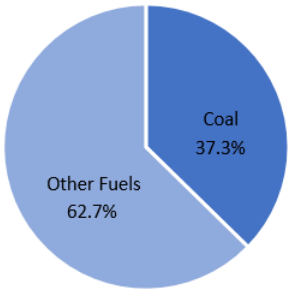
2010 to 2016, mainly from coal-fired power plants. To ensure that local demands are met and to secure future supply, the government set an annual domestic market obligation (DMO) for coal producers and planned a production cap of 400 million tons by 2019.[101,102] However, the feasibility of the government's approach to capping production and discouraging exports has been questioned, given that coal exports generate considerable revenue for the Indonesian government in addition to a recent fall in oil revenue over recent years.[103]

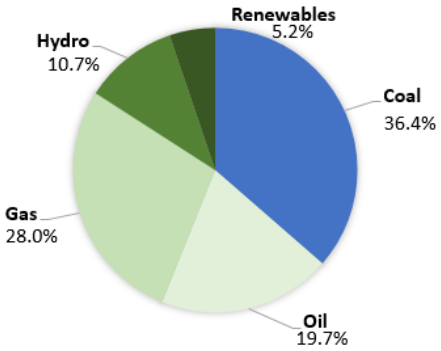
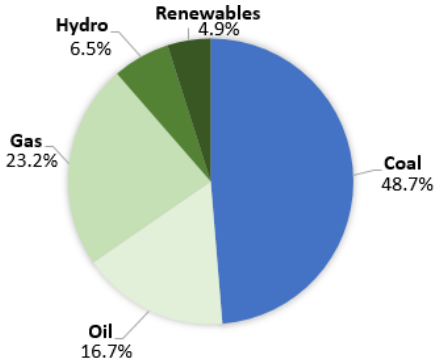
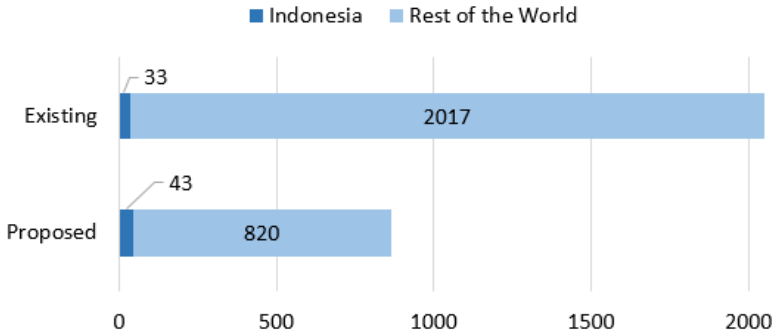
Although, Indonesia's domestic coal use is rising, the extent of this increase remains unclear. After several delays including challenges related to land acquisition and financing, the target of 35 GW of additional power capacity by 2019 (including a large share of coal power plants) was revised downward to 27 GW by 2019, with 77 GW planned by 2026.[104] At the same time, the cap on coal production has, so far, been difficult to enforce.[105]

Public health and environmental concerns challenge coal use

Local environmental impacts and public health concerns have prompted action from civil society as well as local governments to challenge coal use. Indonesia's geographical features have resulted in a large number of small, inefficient coal power plant units that operate well below the design value and lack stringent emission standards.[106,107] These coal plants compound the severe air quality issues originating from forest fires. Estimates suggest that coal power plants around highly dense populations could triple pollution-linked deaths in locations where air pollution related diseases already affect more than half the population[108]. Furthermore, Indonesia's extensive coal mining industry and its poor reclamation practices have negatively impacted rainforests and rivers, with mining activities affecting the water table and irrigation needed for rice paddies.[109] Consequently, civil society action against Indonesian coal power plants has been growing, causing the government to review permits and financiers to reinvestigate their commitments for a number of high profile power projects such as Cirebon, Tanjung Jati and Batang.[110]

Information box – Indonesia

Coal consumption (2016)	Coal production (2016)	Energy system CO_2 emissions (2016)
62.7 Mtoe	255.7 Mtoe	441.9 $MtCO_2$
World Rank 9	World Rank 5	World Rank 13
		

Electricity generation by fuel	2000	2012
		
Existing and proposed coal power generation capacity (MW)		

Data Sources:
Coal production and coal consumption numbers are taken from **BP Statistical Review of World Energy June 2017**
Energy system CO2 emissions are taken from **CO2 emissions from fuel combustion, IEA, 2017**
Information on electricity generation mix for Year 2000 is from **Energy Balances of Non-OECD Countries (IEA, 2015)**
Information on electricity generation mix for Year 2012 is from IEA's report **Energy Policies Beyond IEA Countries - Indonesia 2015**
Existing coal power generation capacity is from **Reudcing emissions from fossil-fired generation: Indonesia, Malaysia, and Vietnam - IEA International Series, 2016**. Proposed coal power generation capacity is from GCAPD own analysis

UNITED STATES

The United States has announced its intent to withdraw from the Paris Agreement, reflecting the current Federal government's priorities, which include enhanced support for the coal industry. However, the US coal industry is under transition as production and consumption of coal have declined in the last decade. Although the current Administration's policies seek to revive coal production and consumption, cheap and abundant natural gas coupled with low energy demand and increasingly inexpensive renewables are rendering coal economically uncompetitive in many contexts. Furthermore, a wide range of public and private actors have stepped up to compensate for the Federal pro-coal policies that are at odds with actions needed for climate change mitigation, thus creating alternative drivers to curb coal use.

Coal industry in the United States is under transition

The electric power sector accounts for over 90% of the coal consumed in the US, making the country the world's third largest consumer of coal.[111] Coal consumption, production, and exports have witnessed a significant decline in the last decade. Even though coal fuels electricity generation, coal consumption has decreased with its annual share of net generation falling from 49% in 2007 to 30% in 2016, driven by a combination of policies, public pressure, and market forces favoring natural gas.[112] As demand in the power sector tapered off, coal production fell by nearly 36% from 2007 to 2016.[113] Furthermore, coal exports that had exceeded 100 million tons in 2012 nearly halved by 2016, primarily due to the economic slowdown in China.[114]

That said, the United States remains one of the world's largest producers of coal. Coal mining is spread across 25 of its 50 states with 5 states accounting for nearly 70% of coal production in 2016. The U.S. also remains a net exporter of coal. Notably, the declining trend in coal production and exports reversed in 2017.[115] However, it is unlikely that this increase will continue as international demand was largely in response to a cyclone that disrupted Australian supply of coal to Asian countries.

The Federal government is supportive of reviving coal

President Donald Trump ran for office partly on the campaign promise of "bringing coal back," and while in office he has implemented policies that seek to reverse the remarkable collapse of the coal industry over the last decade. By the end of 2016, US coal production and coal consumption had declined to about two thirds of 2011 levels. Several American coal firms invested in the expansion of coal to meet anticipated domestic and global demand but subsequently had to file for bankruptcy.[116] In parallel, overall employment in the coal mining sector declined from 90,000 workers in 2011 to about 52,000 workers in 2016, disproportionately affecting counties in coal-rich regions with high concentration of workers in the coal industry.[117] The negative impacts on employment and local economies in these areas have increased support in these areas for President Trump's efforts to revive the industry.[118]

The Trump Administration has acted on its promises to support coal. Previous policies that limited coal production or use have been reversed. Most visible of these has been the announcement in June 2017 of the United States's intent to withdraw from the Paris Agreement. Additionally, the new administration rescinded the Climate Action Plan in March 2017 and announced in October 2017 a formal proposal to repeal the Clean Power Plan that curbs emissions from coal-fired power. Other policies include reducing regulatory requirements for coal production. However, the Administration's pro-coal agenda has not remained

unchecked. A plan by the Department of Energy (DOE) to subsidize coal and nuclear power generation was rejected in January 2018 by the Federal Energy Regulatory Commission (FERC) on the grounds that it favored economically uncompetitive technologies.[119] The decision was welcomed by free-market proponents, environmental groups, the renewable energy industry, and the natural gas industry, which all would benefit from a decline in coal usage.

Market factors dissuade coal use in the power sector

Coal power generation—and therefore coal production—in the US has been on the decline largely due to market fundamentals. 59 GW of coal-fired power plants representing 17% of the US electricity generation capacity retired between 2008 and 2016.[120] There is widespread agreement among various analysts that the major factors driving down coal use were cheap natural gas prices, low energy demand, and low-cost renewables, while environmental regulations only played a minor role.[121,122]

The first and most significant reason for decline in coal power has been the shift to natural gas based power plants even though coal had been the dominant source of electricity generation in the US for several decades. In 2016, natural gas generation exceeded coal-based generation for the first time marking a turning point in the replacement of coal with natural gas.[123] The shift away from coal was clearly driven by several factors, including policies and public pressure. But it's also clear that a major factor was a market-driven response to the steep decline in gas prices after the shale gas boom around 2008-09, consequently making natural gas significantly cheaper and more economically attractive than coal. The US Energy Information Administration (EIA) projects that the production of competitively priced natural gas will continue to dominate over the next decades.[124]

A second reason for the decline in coal power has been a week demand for energy since the recession in addition to the adoption of increasingly efficient appliances. While the year-on-year demand growth was negative in 2017, the EIA predicts slow- to flat-growth over the next decades.[125] Abundant low price natural gas will therefore continue to meet demand, challenging coal use.

The third threat to coal power has been from renewables that have become increasingly competitive. Cost reductions in renewable energy technologies coupled with federal- or state-level incentives to promote their use resulted in solar and wind leading annual capacity additions since 2014.[126] The EIA estimates that wind and solar capacity will continue to increase.

The decline in coal power that was guided by market fundamentals is therefore expected to continue in the future. The EIA projects that competitively priced natural gas and renewable energy will lead to a coal capacity decrease of 65 GW between 2017 and 2030, even in the absence of the Clean Power Plan.[127] Larger decreases in coal power would follow from future environmental regulations, including at the state or local level.

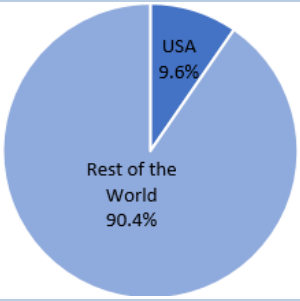
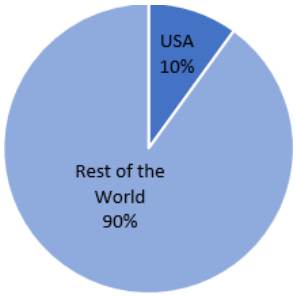
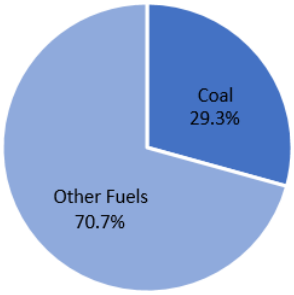
Public and private sector actors contradict federal climate and energy policy

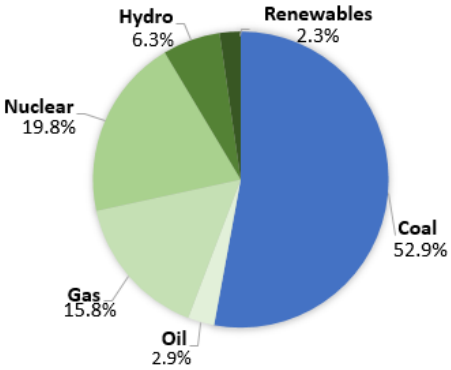
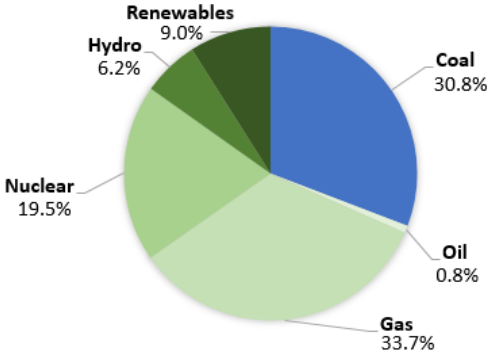
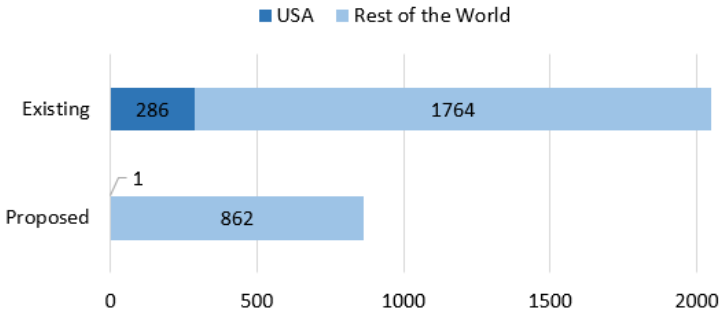
Outside of the relatively narrow band of support from those directly affected, the Trump Administration's pro-coal policies do not align with current public sentiment. Surveys conducted between 2008 and 2017 show that, although deeply divided among party lines, public opinion in favor of the phase-out of coal has

increased over time while support for the government backing of "clean coal" has declined.[128] Furthermore, surveys estimate two-thirds of the US population prioritizes an expansion in clean energy sources such as wind and solar rather than fossil fuels such as coal, oil, or natural gas.[129]

The Administration's energy and climate change actions have therefore been widely questioned by stakeholders outside the federal government. Actions by such stakeholders create opportunities to limit coal use. For example, large businesses that are also major consumers of electricity have increasingly indicated their opposition to consuming coal-fired power and their willingness to purchase wind or solar PV energy.[130] This suggests to utilities that coal power plants may have few buyers. The most prominent challenge in the near term has been seen in the "We Are Still In" coalition that emerged in the days after the US announcement to withdraw from the Paris Agreement. More than 2,500 leaders including from state governments, businesses, and universities, representing 172 million Americans across all 50 US states demonstrated their commitment to upholding the Paris Agreement, including through the use of clean energy.[131] These various stakeholders that include public and private actors have thus created alternative opportunities to curb coal use.

Information box – United States

Coal consumption	Coal production	Energy system CO_2 emissions (2016)
358.4 Mtoe	364.8 Mtoe	4997.5 $MtCO_2$
World Rank 3	World Rank 2	World Rank 2
		

Electricity generation by fuel	2000	2016
		
Existing and proposed coal power generation capacity (MW)		

Data Sources:
Coal production and coal consumption numbers are taken from **BP Statistical Review of World Energy June 2017**
Energy system CO2 emissions are taken from **CO2 emissions from fuel combustion, IEA, 2017**
Information on electricity generation mix for Year 2000 is from **Energy Balances of OECD Countries (IEA, 2015)**
Information on electricity generation mix for Year 2016 is from the World Energy Balances (IEA, 2017)
Existing coal power generation capacity is from **Preliminary Monthly Electric Generator Inventory - EIA, 2017**
Proposed coal power generation capacity is from GCAPD own analysis

JAPAN

Japan is the only G7 country on a trajectory to increase coal use. Coal, along with other fossil fuels, was used to meet energy demand after the Fukushima Daiichi nuclear disaster of 2011, when Japan's entire nuclear power fleet was shut down. The Japanese government continues to actively support coal and specifically considers it a cost-effective and stable source of baseload power supply in an energy-poor country that is heavily reliant on imports of all fossil fuels. As part of its industrial policy, the government also actively supports expansion of coal-fired power internationally with its emphasis on "clean coal" technology. However, meeting challenges faced by Japan's energy sector—including heavy reliance on fuel imports and international pressures to meet emissions targets—would require decreasing the use of coal power.

Japan's post-Fukushima energy policy driving coal power

Japan is the only member of the G7 that continues to invest in coal-fired power generation capacity. Planned investments in 45 new coal-fired power plants aim to replace older, inefficient power plants as well as meet some of the electricity demand after the idling of nuclear power plants following the Fukushima Daiichi disaster. Japan in its 2014 Strategic Energy Plan considers coal a cost-effective and stable source of baseload power supply in an energy-poor country that is heavily reliant on imports of all fossil fuels.[132]

In the aftermath of the Fukushima Daiichi nuclear disaster, public opinion towards nuclear energy soured, with 70% of the population backing a reduction in nuclear energy in 2012, increasing from 44% in 2011.[133] Japan shut down its entire nuclear power plant fleet cutting 28.6% of its entire electricity supply in the year following the disaster.[134] The shortfall caused by the nuclear shutdown was met largely by fossil fuels, i.e., oil, liquefied natural gas (LNG), and coal. The share of coal grew from 25% to 31% between 2010 and 2014 as nuclear power plants were taken offline.[135]

Coal power received a boost after December 2012 with Prime Minister Shinzo Abe's administration and the broader "Abenomics" program. The program was meant to encourage economic growth through structural reforms as well as infrastructure development. The powerful Ministry of Economy, Trade and Industry (METI) implemented several bureaucratic and administrative procedures to facilitate coal power plants. For example, the government slashed the time required for Environmental Impact Assessments (EIA) of coal power plants from three years to one, it cut tendering and approval procedures for new power plants, and it exempted smaller coal-fired power plants representing nearly a third of planned coal power plants from EIA procedures.[136,137]

There has been little opposition to coal from the government, which has not actively included climate considerations in its decision-making. Although the Environment Ministry initially objected to the construction of selected new coal power plants, it reversed its opposition to their construction in 2016 after METI introduced requirements for new coal-fired power plants to have ultra-supercritical-level high efficiency.[138] Ultimately, the pro-business METI that works with Japan's power generation companies and heavy industry continues to make the final decision on the construction of new coal power plants.

Japan expands advanced coal combustion technology domestically and internationally

Japan has responded to mounting international concerns about Japan's unabated coal use, which calls into question their commitments to reducing CO_2 emissions. The country claims that its ultra-supercritical coal

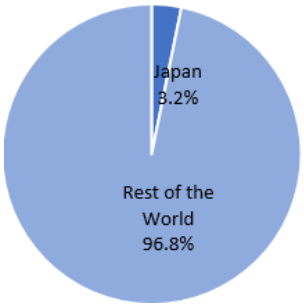
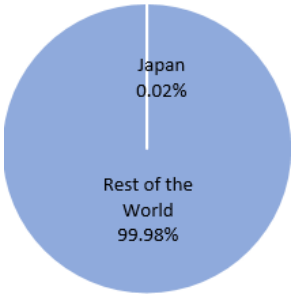
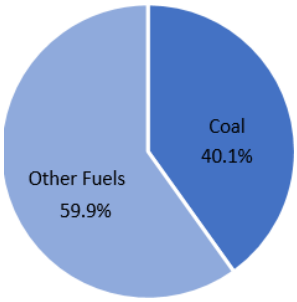
power plants use "clean coal" technology. It also claims that advanced ultra-supercritical (A-USC), integrated gasification combined cycle (IGCC), and integrated coal gasification fuel cell combined system (IGFC) technologies will be increasingly available in the 2020s and 2030s.[139] However, while Japan's coal fleet is the most efficient in the world, coal-fired power generation still emits twice as much CO_2 as LNG-fired generation. To counter emissions, Japan invests heavily in carbon capture and storage (CCS) and has several pilot projects that are ongoing or under construction. While the 2014 Strategic Energy Plan anticipates CCS use after 2020, there are no policies in place to facilitate deployment.[140] Consequently, Japan's measures to check coal use have largely been inadequate.

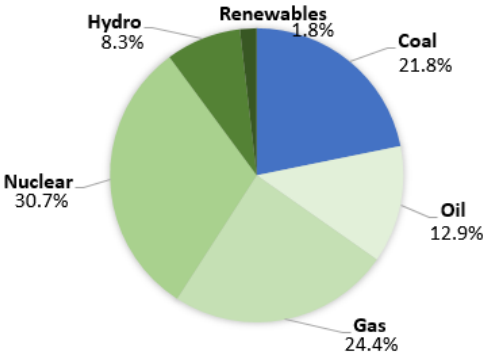
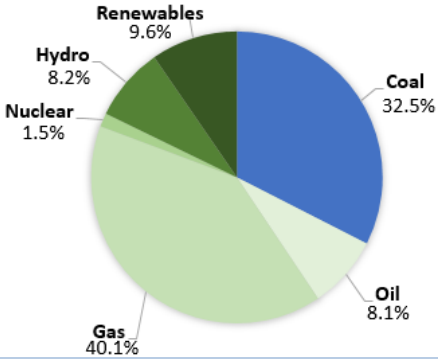
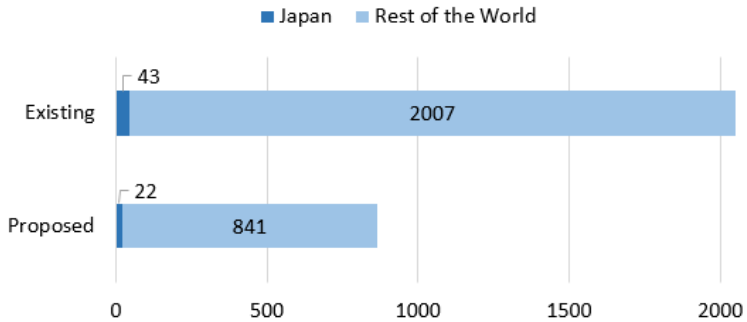
Japan has also supported the expansion of its "clean coal" technology internationally, both as a financier of overseas coal projects and a provider of technology. Between 2007 and 2015, Japan's public financing agencies provided $22 billion to finance overseas coal power plants, including in Indonesia, Vietnam, and India.[141] Japan justifies their support of other country's coal expansion by arguing that these countries already have plans in place to use coal and Japan is only providing access to more efficient technologies to do so. However, this international expansion is also partially driven by export policy and industry, given that Japanese companies including Toshiba, JGC, Mitsubishi Heavy Industries (MHI), and Hitachi are amongst the world's biggest manufacturers of coal technology.[142]

Japan's domestic energy challenges provide opportunities to curb coal use

Japan plans to develop domestic resources to improve self-sufficiency in energy. In 2014 close to 88% of power generation in Japan depended on fossil fuel imports including 31% from coal imports. The majority of these imports were from Australia, with some imports from Indonesia.[143] But improving self-sufficiency in energy, along with the other challenges faced by Japan's energy sector—i.e., high costs of electric power generation and high amount of CO2 emissions[144]—require limiting coal use and thus offer opportunities to reduce the reliance on coal.

Information box – Japan

Coal consumption (2016)	Coal production (2016)	Energy system CO_2 emissions (2016)
119.9 Mtoe	0.7 Mtoe	1141.6 $MtCO_2$
World Rank 4	World Rank 33	World Rank 5
		

Electricity generation by fuel	2000	2014
		
Existing and proposed coal power generation capacity (MW)		

Data Sources:

Coal production and coal consumption numbers are taken from **BP Statistical Review of World Energy June 2017**
Energy system CO2 emissions are taken from **CO2 emissions from fuel combustion, IEA, 2017**
Information on electricity generation mix for Year 2000 is from **Energy Balances of OECD Countries (IEA, 2015)**
Information on electricity generation mix for Year 2016 is from the World Energy Balances (IEA, 2017)
Existing coal power generation capacity is from **Coal Industry Advisory Board Paper - IEA, 2015**. Proposed coal power generation capacity is from GCAPD own analysis

SOUTH KOREA

South Korea underwent an expansion in coal power plant capacity in the last decade. However, emerging concerns about air pollution and public health have reversed the country's coal use. The new government elected in 2017 decided to phase out old power plants and is reconsidering planned construction. Plans for renewable capacity expansion coupled with the continued construction of two new nuclear power plants indicate near-term power supply stability and also decrease the need for coal. Efforts are being made to reduce public financing of overseas coal power plants. However, the long-term future of coal remains subject to changes in the national political context.

South Korea is heavily reliant on imports of fossil fuels, including coal

South Korea relies heavily on imports of coal and other fossil fuels because of inadequate domestic resources. In 2015, South Korea was the world's fourth largest importer of coal, with imports primarily from Australia, Indonesia, and Russia.[145] Overall, South Korea imported 98% of its fossil fuel consumption[146].

The rapid expansion in coal-fired power capacity increases their reliance on coal imports. The electric power sector is the largest consumer of coal, accounting for over 60% of coal used in 2016. Coal's share in electricity generation was about 40% in 2016.[147] Coal capacity expanded from just over 22 GW in 2008 to around 36 GW in the beginning of 2018.[148]

Concerns about air pollution drive anti-coal policy

The newly elected President Moon Jae-in entered office with pledges to improve environmental conditions in South Korea. The concerns over air pollution were particularly timely given overlap of the 2017 presidential election with one of the country's worst air quality seasons in history. South Korea has some of the highest levels of air pollution among OECD countries. The OECD predicts that by 2060, premature deaths directly attributed to air pollution would reach about 54,000 people per year, or about 1,109 per million population—also the highest among OECD countries.[149]

While the government has historically blamed drift from China for its air quality conditions, recent evidence suggests that local sources including coal power plants, vehicular emissions, and industry contribute to over half of the pollution issues.[150]

President Moon had promised to phase out coal and nuclear, while increasing the share of renewable energy capacity from 9.7% to 33.7% by 2030, accounting for 20% of generation.[151] The government announced in May 2017 that it would shut down 10 coal-fired power plants that were older than 30 years by 2022.[152] In the meantime, these power plants would be halted temporarily in off-peak months to offer respite from pollution. There were nine planned coal power plants that the Moon Administration opposed. However, Moon backed away from his original position and is likely to allow seven of them to be built, while switching two of the plants to natural gas plants.[153] New policies that limit coal use are projected to cut air pollutants from power generation by 62% by 2030.[154] Some provincial governments have expressed their opposition to a future with coal-fired power. For example, in the South Chungcheong province, home to a large number of coal power stations, the Governor expressed strong anti-coal sentiment, declaring his province 'post-coal'.[155]

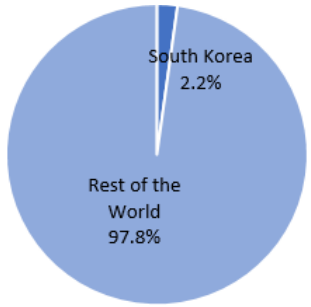
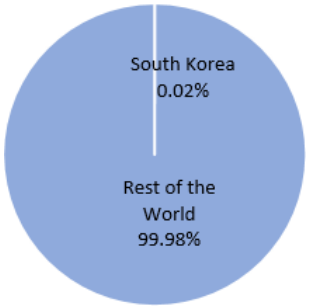
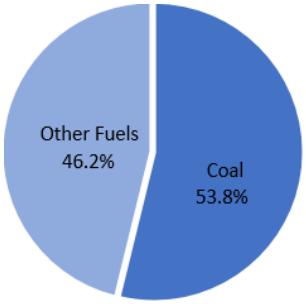
Capacity surplus provides an opportunity to switch from coal to low carbon energy

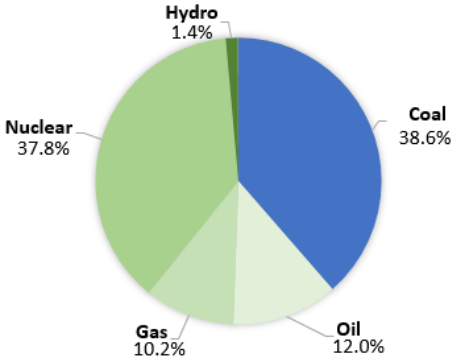
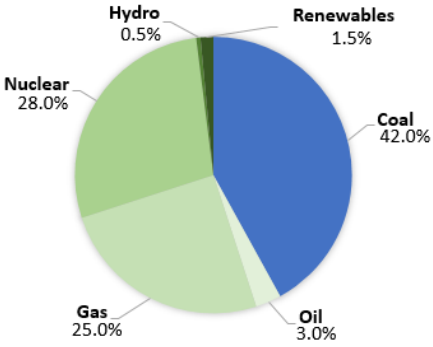
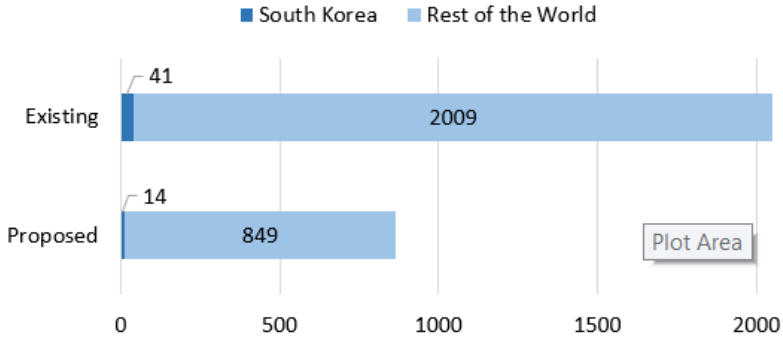
Three key features that characterize the future of South Korea's power generation sector also provide impetus to constrain coal development and utilization. First, the demand for energy in South Korea has slowed with decreasing economic growth rates and more rapid improvements in energy efficiency. Forecasts estimate a demand of 100.5 GW by 2030 with a low annual growth rate of 1.3%; these estimates conducted in 2017 are 11% lower than the estimates provided in 2015.[156] Second, even with the temporary halts in coal plant use for mitigating air pollution, South Korea does not face an electricity supply deficit, at least in the off-peak months. The reserve margin in the power sector, i.e., the capacity in excess of peak demand, is currently 20% and planned to be 22% by 2030.[157] And third, after a consultative process that revealed public support for nuclear power, the government decided to continue construction of two nuclear power plants.[158] In the long-term, the new administration plans to increase renewable power generation to 20%. The combination of these factors ensures stability in power supply, even without the use of coal, and provides opportunities to shift from coal to other energy sources.

The government increasingly questions the financing of overseas coal projects

Despite these domestic trends for power generation, South Korea has been the world's third largest financier of overseas coal power plants in the last decade. Its public institutions, most notably the Korea Export Import Bank (KEXIM) and the Korea Trade Insurance Corporation (K-sure), have provided more than $8 billion in financing of coal plants, including in Indonesia, Vietnam, India, and Chile.[159] Recent developments challenge the financing of coal plants. For example, bills have been introduced in the National Assembly calling for greater scrutiny of coal investments by various financing institutions, starting with KEXIM.[160]

Information box – South Korea

Coal consumption (2016)	Coal production (2016)	Energy system CO_2 emissions (2016)
81.6 Mtoe	0.8 Mtoe	586.0 $MtCO_2$
World Rank 7	World Rank 31	World Rank 7
		

Electricity generation by fuel	2000	2016
		
Existing and proposed coal power generation capacity (MW)		

Data Sources:
Coal production and coal consumption numbers are taken from **BP Statistical Review of World Energy June 2017**
Energy system CO2 emissions are taken from **CO2 emissions from fuel combustion, IEA, 2017**
Information on electricity generation mix for Year 2000 is from **Energy Balances of OECD Countries (IEA, 2015)**
Information on electricity generation mix for Year 2016 is from **IEA's information on Korea's Energy System Overview**
Existing coal power generation capacity is from **Korea Electric Power Corporation's Monthly Report on Major Electric Power Statistics (June 2017).** Proposed coal power generation capacity is from GCAPD own analysis

CONCLUSIONS

The continued development, investment in, and production of coal power threatens the ability of the world to hit global climate goals and for countries to achieve their near-term climate targets. Nevertheless, there is hope for reaching these targets with immediate action. Our assessment focuses on the opportunities to reduce proposed coal capacity globally, and indicates that a clear, significant, and low-cost step toward reaching national and global goals is to dramatically curtail planned and proposed capacity.

Limiting warming to below 2°C would nevertheless require much more significant changes. Not only would countries need to halt the construction new plants, but they would also need to accelerate the retirement of existing plants. Moreover, failure to cancel these plants now could end up being extraordinarily costly by creating large quantities of infrastructure that would need to be retired significantly earlier than their planned lifetime: specifically, any new addition of coal power generation capacity from today would subsequently have to retire prematurely in the post-2030 period for the world to have a significant chance of achieving long-term climate goals.

Stronger policy efforts would be necessary to address these issues for coal power generation and new construction. In many countries, such policies must be implemented as part of comprehensive strategies to ensure simultaneous progress toward development goals for energy access and energy security. The rapidly changing technological and economic landscape in energy raises the possibility that solutions can be found that can achieve multiple goals for development and sustainability that do not rely on the detrimental build-out and utilization of coal-fired electric power.

APPENDIX: Additional Figures and Tables

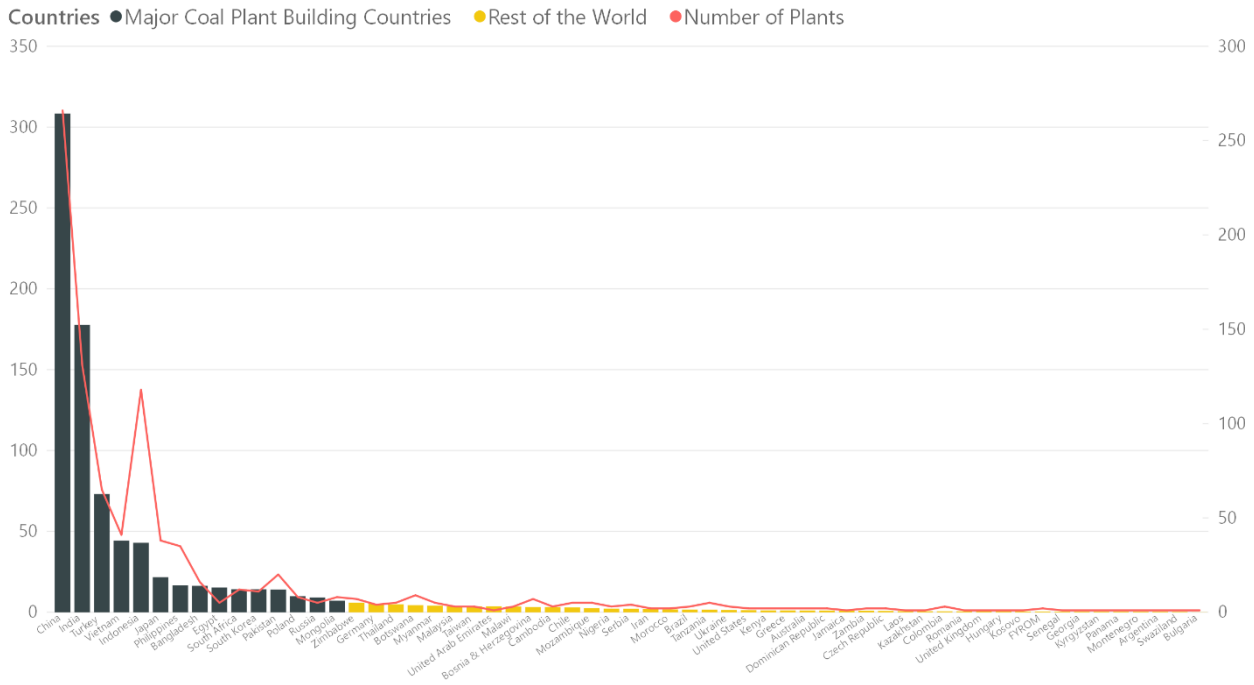


Figure A1. Proposed coal-fired power plants and capacity by country

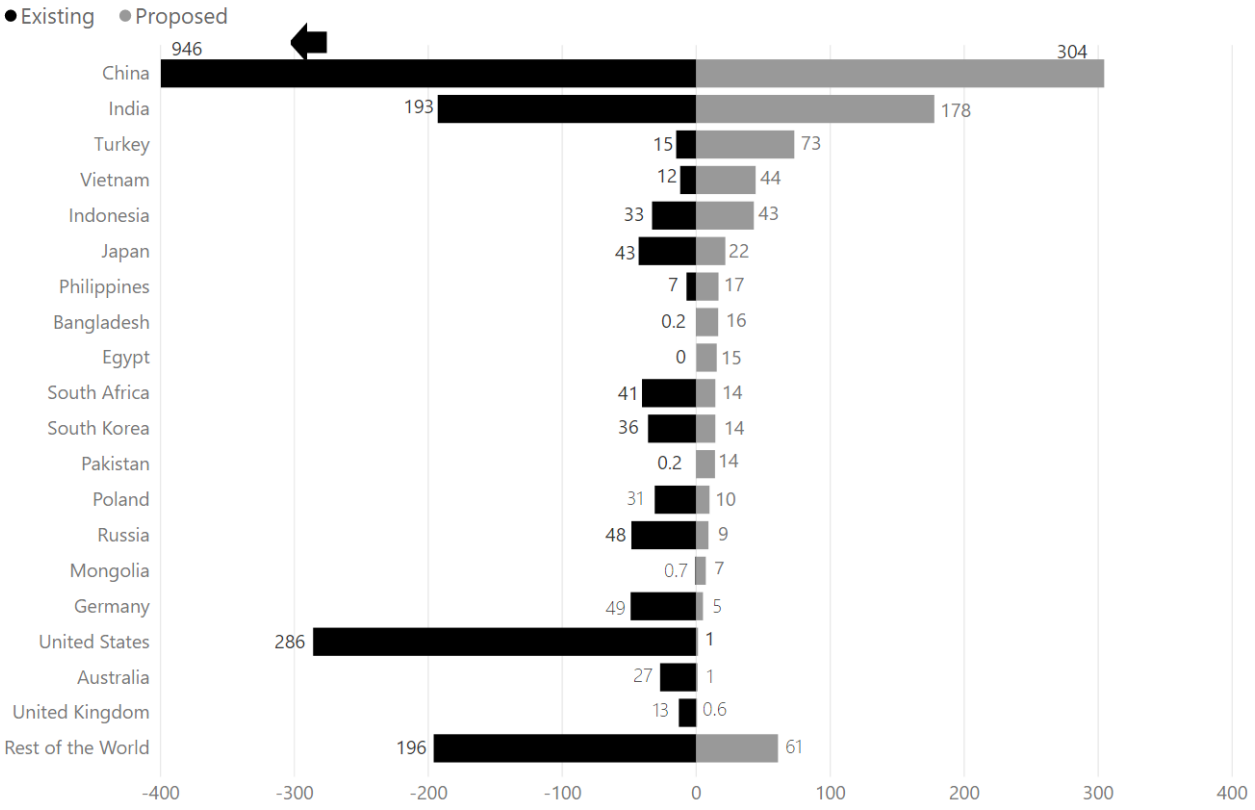
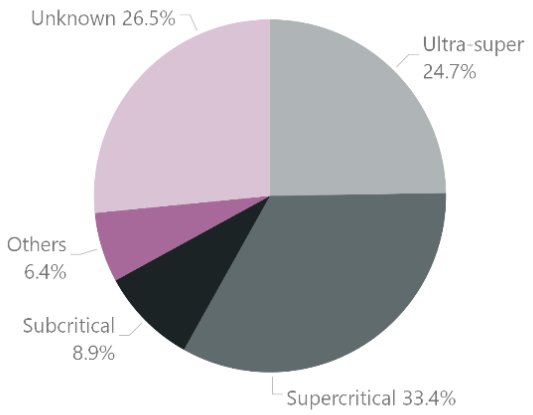


Figure A2. Existing and proposed coal power generation capacity by country



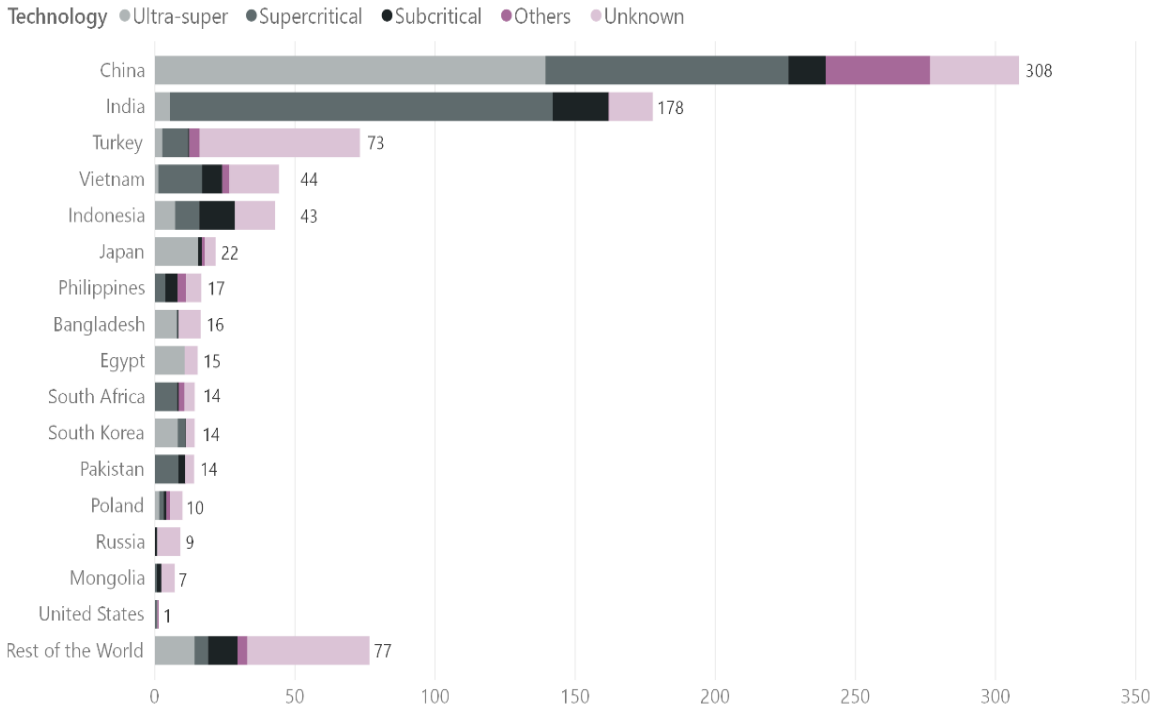


Figure A3. Proposed Coal Power Plants by Technology, Share and Capacity (GW)

Table A1. Proposed Coal Power Plants under Development, by Country and Status*

Country	Construction (MW)	Permitted (MW)	Permitting (MW)	Planning (MW)	Total (MW)	Total # of Units
Argentina	240				240	2
Australia			150	900	1050	3
Bangladesh	2915		3905	9540	16360	28
Bosnia & Herzegovina		1350	350	1500	3200	10
Botswana	432	1500	300	2104	4336	21
Brazil	680	600	300		1580	5
Bulgaria	50				50	1
Cambodia	135	540	500	2000	3175	7
Chile	725	835	1360		2920	9
China	104159	23100	151690	29480	308429	567
Colombia	250	200	150		600	3
Czech Republic	780				780	4
Dominican Republic	700			300	1000	3
Egypt			2640	12620	15260	19
FYROM			125	300	425	2
Georgia			300		300	1
Germany	1100		2000	2000	5100	5
Greece	660			450	1110	2
Hungary			500		500	1
India	49008	22646	67505	38520	177679	263
Indonesia	8821	2900	11634	19609	42964	208
Iran	2050				2050	6
Jamaica				1000	1000	1
Japan	3610	2983	11608	3470	21671	44
Kazakhstan	636				636	1
Kenya	66		1050		1116	4
Kosovo			500		500	1
Kyrgyzstan	300				300	2
Laos				700	700	2
Malawi		420		3100	3520	11
Malaysia	3600				3600	5
Mongolia	1400	1200	900	3600	7100	15
Montenegro			254		254	1
Morocco	1386	318			1704	3
Mozambique		600	500	1500	2600	8
Myanmar		500	50	3520	4070	8
Nigeria			1200	1000	2200	6
Pakistan	4080	5601	2675	1620	13976	31
Panamá	300				300	2
Philippines	4565	3510	5743	2770	16588	67

Poland	2788		5490	1600	9878	17
Romania			600		600	1
Russia	373		226	8480	9079	8
Senegal			350		350	2
Serbia			350	1800	2150	6
South Africa	7940	2610	1380	2300	14230	27
South Korea	4867	2080	4760	2500	14207	16
Swaziland				200	200	1
Taiwan	3600				3600	5
Tanzania		600	670	270	1540	12
Thailand	600		2850	1450	4900	7
Turkey	3085	9260	37075	23760	73180	85
Ukraine	45		660	690	1395	9
United Arab Emirates	2400			1200	3600	6
United Kingdom			570		570	1
United States	400	895			1295	2
Vietnam	14217	2520	15910	11650	44297	91
Zambia		600		300	900	4
Zimbabwe		5250		600	5850	16
Total	**232963**	**92618**	**338780**	**198403**	**862764**	**1698**

* Based on data by August 2017

Table A2. Proposed Coal Power Capacity under Development, By Country and Technology*

Country	Subcritical (MW)	Supercritical (MW)	Ultra-supercritical (MW)	Other (MW)	Unknown (MW)	Total
Argentina				0	240	240
Australia				0	1050	1050
Bangladesh	275	400	7775	0	7910	16360
Bosnia & Herzegovina	550			950	1700	3200
Botswana	1936			0	2400	4336
Brazil				680	900	1580
Bulgaria				50		50
Cambodia	675			0	2500	3175
Chile		1360		0	1560	2920
China	13319	86730	139380	37360	31640	308429
Colombia				0	600	600
Czech Republic		660		0	120	780
Dominican Republic				0	1000	1000
Egypt			10620	0	4640	15260
FYROM	300			125		425

Georgia	300			0		300
Germany				0	5100	5100
Greece				0	1110	1110
Hungary		500		0		500
India	19916	136690	5320	313	15440	177679
Indonesia	12720	8625	7215	0	14404	42964
Iran				0	2050	2050
Jamaica				0	1000	1000
Japan	1352		15435	1080	3804	21671
Kazakhstan		636		0		636
Kenya	66	1050		0		1116
Kosovo	500			0		500
Kyrgyzstan				0	300	300
Laos				0	700	700
Malawi	1120			0	2400	3520
Malaysia			3000	600		3600
Mongolia	1600	700		0	4800	7100
Montenegro		254		0		254
Morocco		318	1386	0		1704
Mozambique	600			300	1700	2600
Myanmar	250		2000	0	1820	4070
Nigeria	1200			0	1000	2200
Pakistan	2459	8372		55	3090	13976
Panamá				0	300	300
Philippines	4410	3720		3000	5458	16588
Poland	1000	1600	1525	1263	4490	9878
Romania				0	600	600
Russia	886			0	8193	9079
Senegal				0	350	350
Serbia	1100			0	1050	2150
South Africa	600	7940		2040	3650	14230
South Korea	250	2695	8182	0	3080	14207
Swaziland				0	200	200
Taiwan			3600	0		3600
Tanzania	550			0	990	1540
Thailand			600	0	4300	4900
Turkey	435	9210	2640	3700	57195	73180
Ukraine				0	1395	1395
United Arab Emirates			3600	0		3600
United Kingdom				570		570
United States		895		400		1295
Vietnam	7160	15702	1200	2560	17675	44297

Zambia				300	600	900
Zimbabwe	1350			0	4500	5850
Total	**76879**	**288057**	**213478**	**55346**	**229004**	**862764**

* Based on data by August 2017

Table A3. Projected Emissions (in MTCO2) from Coal Power Generation for Major Countries in 2030 by Project Development Status

Country	Existing	Anticipated Retirement	Construction	Permitted	Permitting	Planning	Suspended Projects (China)
China	3,486	1,266	433	93	613	116	645
India	973	319	226	102	303	166	-
United States*	1,251	727	2.04	4.49	-	-	-
Indonesia	152	30	42	13	54	88	-
Japan	170	98	17	14	54	16	-
South Korea	184	75	31	13	29	15	-
Global Total	**11,207**	**3,736**	**1,139**	**396**	**1,517**	**1,585**	**645**

* 2025 numbers are reported

Table A4. Projected Emissions (in MTCO2) from Coal Power Generation for Major Countries in 2030 for 2°C and Paris-NDC scenarios

Country	Continue coal growth	Paris-NDC	2°C
China	4,120	4,811	1,321
India	1,451	1,742	422
United States*	531	968	1,130
Indonesia	319	1,098	45
Japan	173	258	117
South Korea	197	174	58
Global Total	**12,453**	**9,953**	**3,153**

* 2025 numbers are reported

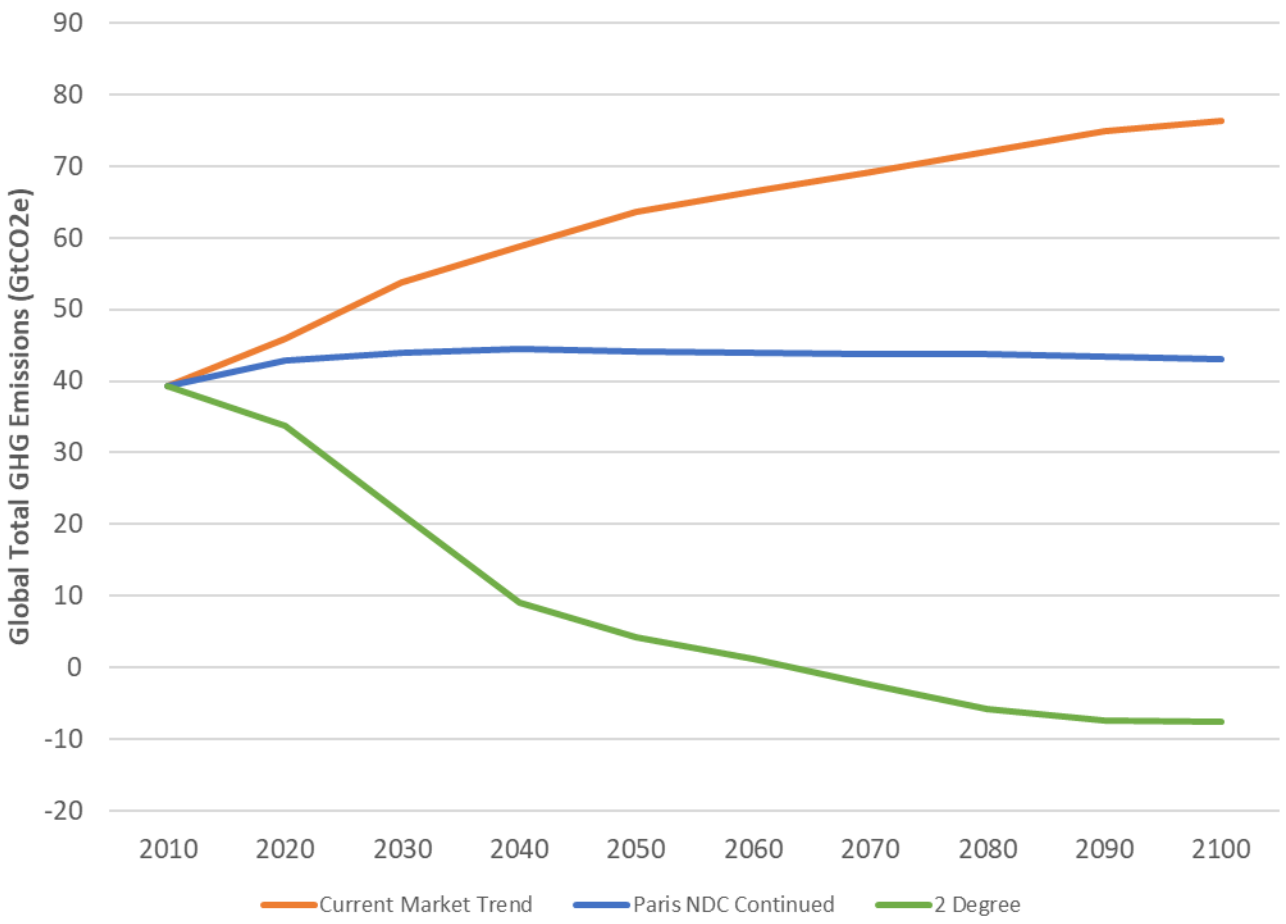


Figure A4. Global total GHG emissions under the continued coal growth scenario, the Paris-NDC-continued-ambition scenario and the 2°C scenario

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