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Addressing the Climate Emergency

Closing 1,000 Gigawatts of Coal Plants by 2035

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Key takeaways

- In order to have any chance of limiting global warming to well below +2°C, there is no choice but to tackle coal-fired power plants head-on, around the world. This means stopping any new construction starts now and launching a new global initiative to close 1,000 GW of the operating fleet by 2035.

- 500 GW would be closed by 2030 in the United States, China, Europe, Japan, South Korea and Australia.

- The G7 should accompany the accelerated closure of 500 GW of capacity in emerging economies and support investment in a low-carbon substitution system. The total cost may be estimated at approximately $1.7 trillion. The G7 would set up a $425 billion fund covering 25% of these costs in the form of grants, with the European Union taking a $140 billion share.

- Assuming a CO_2 price of $150/tonne and a reduction of CO_2 emissions totaling 25 Gt associated with the 500 GW coal emission neutralization, the gain for the planet would be a net $2 trillion. And this is not to mention the hundreds of billions of investment from the private sector, notably by European companies and local partners.

INTRODUCTION

Facing the environmental and climate threats, it is now urgent time for resolute and effective action. It is adamant to raise national determined contributions by summer ahead of COP26 and to rapidly obtain results in significantly and lastingly curbing greenhouse gas emissions. The 2020 decline was largely insufficient for a 1.5°C trajectory. 2021 will probably erase much of that short-lived victory.

The G7 has been revived and the global climate governance has been revigorated by the return of the United States (US) to the Paris Agreement. 2021 comes with decisive diplomatic sequences yet the US-China confrontation brings uncertainties at times when cooperation is needed. More efforts and new initiatives are required, alongside delivering on commitments.

The world needs to tackle much harder the decarbonization of global electricity systems and accelerate the electrification of end-uses. With over 2,200 gigawatts (GW) of installed coal-fired capacity worldwide producing 35% of electricity in 2020, with a large part of that fleet recently built, there is no choice but to tackle coal-fired power plants head-on, around the world, in order to preserve the climate, the environment and health. This coal power generation accounts for approximately 10 gigatons (Gt) of CO_2 emissions, that is about 28% of total CO_2 emissions in 2019.[1]

A first objective should be to immediately stop any new construction

A first objective should be to immediately stop any new construction starts now and to have first a G7 and then a G20 commitment to immediately stop direct and indirect coal financing. Companies and/or governments cancelling their projects should be able to call for support in planning and financing alternatives, and international energy governance institutions, alongside multilateral financial organizations, should be mobilized to help them. In turn, those still sticking to more or new coal, six years after the Paris Agreement, should bear a high political cost.

A new international initiative should be launched with a view of closing 1,000 GW of the operating fleet by 2035 and supporting an additional wave of investments into clean alternative systems. In total, this should allow saving about 3 Gt of CO_2/year, that means as much as the combined annual emissions of the aviation, maritime transport and hydrogen segments in 2019, or almost as the 27-member European Union (EU-27) emissions. This note discusses issues at stake and proposes a framework for action.

1. IEA, *Global Energy & CO_2 Status Report 2019*, Paris, March 2019, available at: www.iea.org; M. Crippa *et al.*, *Fossil CO_2 Emissions of All World Countries – 2020 Report*, EUR 30358 EN, Publications Office of the European Union, 2020, available at: https://ec.europa.eu.

COAL IS IN AN ENCOURAGING DECLINE TRAJECTORY, YET BY FAR NOT SUFFICIENT

About two thirds of global coal demand comes from the electricity sector, the rest being used in industry, notably steel, or petrochemicals (for hydrogen production) or for cement production. Global coal demand has doubled during the period 1998-2013, but peaked in 2013 and has declined by 10% in the period 2013-2019.[2] This trend is particularly accurate in economies from the Organisation for Economic Co-operation and Development (OECD), where demand has been in a 30% decline over the past thirty years. Yet demand has been soaring in emerging economies and outpaced that decline, notably in China, where it tripled between 1990 and 2013 and now amounts to half of global demand.

Coal comes with an important social footprint

Coal comes with an important social footprint, with million workers employed in mining and power generation notably (3.6 million direct and indirect jobs in China), often in poor regions. In Poland for example, coal employs 80,000 people, yet on a 20 years period going forward, many of these workers will go into retirement and jobs can be transferred to other sectors through reskilling policies.

China accounts for almost half of global coal fired power generation capacity. Ultra-supercritical coal plants represent about one-third of total installed coal power generation capacities globally, yet a majority in China. These are more efficient and less polluting than older generation plants, and allow to reduce emissions of particles. They emit on average 750 g CO_2/kWh (grams of CO_2 per kilowatt-hour), against an average of 900 g CO_2/kWh for the entire coal fired power generation fleet.[3] As a matter of comparison, the average emission level from the world's electricity generation mix is at 340 g CO_2/kWh.[4] So, the coal fired power generation fleet comes with much too high emissions and externalities. Could one envisage installing large scale carbon capture and storage (CCS) systems on these plants? In theory, yes, and the problem could be largely solved. In reality, this cannot happen at the required scale and in the foreseeable future: most of the plants do not have appropriate and competitive infrastructure nearby as these systems are expensive. This would require, where it is technically possible, to have either large subsidies in place, or a high carbon price and electricity tariff, conditions that can hardly be met. In China for example, in spite of many CCS projects, almost nothing was done, for cost reasons, and due a lack of export market perspectives.[5] In developed economies, coal plants can be closed or abated with CCS and can be replaced with low carbon solutions or gas plants coupled with CCS or dual, using biomethane or clean ammonia/hydrogen. Yet that comes with a cost, of course.

2. IEA, *World Energy Outlook 2019*, Paris.
3. IEA, "Average CO_2 Intensity of Power Generation from Coal Power Plants, 2000-2020", available at: www.iea.org.
4. IEA, "Global CO_2 Emissions in 2019", February 11, 2020, available at: www.iea.org.
5. S. Cornot-Gandolphe, "Carbon Capture, Storage and Utilization to the Rescue of Coal? Global Perspectives and Focus on China and the United States", *Études de l'Ifri*, Ifri, June 2019, available at: www.ifri.org.

As for coal use in the electricity sector, there is a very clear slowdown of construction of new coal power plants in the world. In 2019 for the first time, there was a net decrease in total installed capacity and electricity generation from coal was down six percentage points since 2014. 2020 confirmed the downward trend in the role of coal in electricity generation and the increase in the share of low-carbon sources: the economic attractiveness of coal-fired power plants is being undermined by competition from solar and natural gas. Societal resistance to new projects is also an emerging constraint for potential customers, and some governments or local authorities have become more sensitive to pollution and climate issues. Financing new plants will be increasingly difficult, if not impossible, on markets. The African Development Bank has finally stopped all coal financing (which it did in the name of fostering energy access) and OECD based banks are also starting to seriously curb their coal financing operations. Yet it took them long to do so and obviously and Japanese and US banks are highly exposed (alongside Chinese banks).[6] As a sign of change, Japanese companies and banks have announced that they will gradually cease financing coal abroad, having contributed significantly to financing the rise of coal-fired power plants around the world over the last two decades. The load factors of operating power plants are thus generally falling (around 55% in China and India). With the COVID-19 related crises, the pace of growth in electricity demand in emerging economies may have slow down a bit, providing a temporary relief from the electricity emergency situation many emerging economies have been struggling with over past years. Moreover, 2020 has seen green finance booming with major progress realized with the European taxonomy and global coordination efforts underway. Lastly, coal extraction in many countries requires subsidies, which governments can now reallocate as low carbon energy solutions can bring an even greater job volume and value creation with huge benefits on economic growth, health and well-being.

A very clear slowdown of construction of new cold power plants

With the crises related to COVID-19, and the European coal phase out policies, there is a risk though: coal prices could fall, giving coal another temporary competitive edge, while governments in emerging economies could seek to keep those jobs and save their economies with cheap electricity. Moreover, being very concerned by its energy security, China could also seek to maintain a high share of coal fired power generation in the coming years.

All in all, the point is: the decline in coal fired power generation capacity, and production, is encouraging, yet is not fast enough to keep the world in a well below +2°C trajectory. Policy action is needed to accelerate this trend.

6. *Banking on Climate Change: Fossil Fuel Finance Report 2020*, Oil Change International, March 13, 20210, available at: http://priceofoil.org.

500 GW OF CAPACITIES CAN BE CLOSED IN CHINA AND IN OECD COUNTRIES BY 2030

On the basis of data from the International Energy Agency (IEA),[7] the following estimate can be made:

- Half of the 150 GW in coal capacity installed in the EU should close, according to current commitments for 2030. Shutdowns will need to be accelerated so that two-thirds of the capacity is phased out by then, or 100 GW. Germany will have to make further efforts. This will be possible thanks to the expected increase in carbon prices in Europe, reducing or even wiping out the profitability of lignite-fired power plants. Interconnections between markets, energy efficiency and renewable energies will compensate for the loss of these production capacities. However, it will be essential that France maintains a substantial nuclear power base over time, that Belgium keeps its two reactors in operation after 2025, and that Central European countries bring new reactors on-line, notably in Poland, the Czech Republic and Hungary.
- In the United States, 222 GW of installed coal capacity is more than 30 years old. By 2030, all of this capacity could be closed or, where possible, coupled with CO_2 storage. While President Biden is likely to face major difficulties in decarbonizing gas-fired power generation, he should at least succeed in closing or abating coal plants, and doing so quickly.
- In China, 35 GW of coal capacity is over 30 years old, and 107 GW over 20 years old. These plants could be shut down (equivalent to 142 GW), and be replaced by more nuclear and power generation from renewable energy sources, in the coming years.
- Japan should not only commit to ending financing coal projects abroad, but also to close at least 20 GW out of 46 GW. Australia could close at least about 15 GW (out of 23 GW) and South Korea could reduce its capacity from 35.8 GW to 15 GW by 2030, that is below the currently envisaged plan.

In total, these administrative and economic measures (power plants technically at end-of-life, carbon prices or regulatory obstacles) concern over 500 GW – half of the targeted effort – and can be implemented without international initiatives, owing to the economic and technical decisions taken by companies or national governments.

7. IEA, “Global Coal-fired Power Capacity by Plant Age, 2018”, July 7, 2020, available at: www.iea.org.

AN INTERNATIONAL MECHANISM TO ACCELERATE THE CLOSURE OF 500 GW IN EMERGING ECONOMIES

So how can an additional 500 GW of coal-fired power generation capacities in emerging economies be closed by 2035, at least ten years before their technical end-of-life?

Estimating the cost of these closures

These countries and companies will not do this voluntarily, because these coal power plants play an important role in their electricity generation and are not amortized. There is no alternative but to help them financially in order to close these plants at least ten years before their technical end-of-life and develop equivalent low-carbon capacity. Or, where possible, equip these plants with CCS infrastructure.

In fact, shutting down coal is more than ever in these countries interest. This can help fight climate change, which is a daunting threat to many of them (food security, water availability, work productivity, physical destructions from extreme weather), and improve health of their population, thus reducing health costs and raising productivity. Newly, this can allow them to reduce their exposure to carbon related direct or indirect border adjustment measures for their exporting industries (notably via the proposed carbon border adjustment mechanism or equivalent carbon levies). Volunteering countries could actually even obtain support through various forms (development aid, trade, capacity building). Lastly, their international attractiveness would be raised, with potential positive impacts on their investment rating and foreign direct investment levels. One could even envisage linking up such commitments to ongoing discussions about debt relief programs.

This can help fight climate change

Assuming that 20% of these plants could lend themselves to this technology, CCS infrastructure would have to be financed for about 100 GW, or for more than 100 plants. Then there remains the need to organize and finance the closure of 400 GW in capacity, and construct low-carbon capacities providing equivalent annual production and security of supply, both from a physical and competitiveness point of view in countries where energy costs are of great social and economic importance.

These 400 GW coal-fired power plants are no longer brand new, so they are already partially amortized. Their new value, if built overnight with the latest technology, would be about $3.6 billion per GW, or $1.5 trillion in total.[8] As these are plants that are built based on cheaper technologies, such as Chinese, one can assume that their overnight costs is about $800 million per GW (totaling $320 billion), and as they are already a few years old, it may be assumed that their depreciated value is now less than $400 million per GW, that is $200 billion. Hence, we can assume that the value of these 400 GW will be around

8. IEA, "Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2021", February 2021, available at: www.eia.gov.

$150 billion by 2025. About $150 billion would thus have to be raised to buy them back and close them. But that would not be enough, as it would be necessary to rehabilitate sites, compensate or re-employ the thousands of workers who depend on this activity. One can assume that this would add another $100 billion in costs.

Economically viable alternatives that can ensure security of supplies

Several assumptions need to be made to understand how 400 GW of power plant capacity can be replaced without undermining the countries' security of supply and affordability of electricity. The first is that these coal-fired power plants operate at 60% of their capacity, producing 5.22 Terrawatt Hour (TWh) annually per GW installed, or a total of 2,088 TWh. This is more than India's annual electricity consumption in 2018 (1,450 TWh), but less than the consumption of the EU-28 the same year (2,800 TWh). The second assumption involves choosing a diverse mix of technologies to replace these coal-fired plants: we could assume using a mix of nuclear, wind, and combined-cycle gas power plants with the optionality to be later coupled with CCS, biomethane or clean hydrogen/ammonia, and, to a lesser extent, concentrated solar power (CSP - the latter allows electricity to be provided for four hours after sunset).

Choosing a diverse mix of technologies

To identify the cost of constructing these alternatives, it is necessary to determine what is called the levelized cost of energy (LCOE) of such technologies, which includes the average costs of construction, capital, operation and decommissioning. To this end, it may be assumed that in 2025 this cost would be $60/MWh for nuclear power (with 7,000 running hours), $35/MWh for land-based wind power, $120/MWh for combined-cycle gas power plants (with 1200 running hours and an optionality for CCS or clean gas utilization), $50/MWh for CSP, and $20/MWh for ground-based photovoltaic (PV) solar power. These would require fine tuning, depending notably on the weighted average cost of capital, and notably, the country or company risk/notation. In any case, it will be important to rely on a mechanism that can help reduce as much as possible the cost of capital and associated risks in order to reduce the LCOE and overall costs of the new, low carbon electricity system[9].

Let us suppose, arbitrarily (as each coal plant must be specifically addressed according to local circumstances), that the 400 GW producing 2,088 TWh annually is replaced with a system consisting of a mix of 20% nuclear, 20% onshore wind, 10% gas plants, 30% PV and 20% concentrated solar power. Based on this breakdown, the table below provides an estimate of the technology replacement costs, totaling $948 billion.

9. U.K. Department for Business, Energy & Industrial Strategy, "Electricity Generation Costs 2020", August 2020, available at: https://assets.publishing.service.gov.uk.

Technology	LCOE	Deployment Cost
Nuclear	$60/MWh	$250 billion
Onshore wind	$35/MWh	$145 billion
Gas	$120/MWh	$240 billion
CSP	$50/MWh	$208 billion
PV	$15/MWh	$105 billion

These calculations exclude the costs of building transmission and distribution networks, which may be estimated at 50% of the total, or about $475 billion. Such investments are normally financed by increasing the network tariffs and ultimately by final consumer bills. Purchasing power is of course extremely limited in emerging countries. A large part of these costs must therefore be included in funding plans. The resulting estimated total is thus about $1.4 trillion.

To understand the economic implications of the decision to equip 100 GW of coal-fired power plants that could use CCS, an assumption must be made about the average CO_2 emissions per kWh. Here, we have opted for 1 kg of CO_2/kWh (in practice, emission levels depend on the quality of coal, the type of power plants and turbines used, on maintenance, etc.). On this basis, nearly 1 million tons of CO_2 are emitted annually for each TWh produced. That is over 500 million tons of CO_2 for 522 TWh of electricity. Assuming that the cost of sequestration and storage of CO_2 stands at $55 per ton of CO_2 on average, this represents an additional cost of $27.5 billion.

The total cost of putting 400 GW of coal plants in early retirement, dealing with the workforce, deploying an alternative, low carbon electricity system alongside abating emissions from 100 GW of coal plants through CCS, on the basis of these assumptions, can thus be estimated at a total of around $1.7 trillion.

This sum could be distributed among the local power producers and investors (so that they avoid stranded costs and reputational risks), the governments of countries where plants operate (to foster their stability and attractiveness), and the G7 which would set up a fund to provide grants in support of these investments. Eligible companies and governments would commit to rule of law, an effective regulatory environment, and fair tender procedures. On the basis of allocating 25% of the total programme costs to local energy providers, 25% to the governments of the countries concerned, 25% to private investors (such as European energy companies interested in investing into the alternative solutions), and 25% to G7 in the form of a subsidy, the G7 governments would therefore have to disburse $425 billion. Assuming that the EU will pay one-third, the United States one-third, and Canada, Japan, and the United Kingdom one-third, this would amount to about $140 billion in total for the EU.

The EU could draw half these funds from its total development aid contributions, for example €10 billion per year during several years and collect the other half, or about €70 billion, in issuing 20-year green bonds. In total, assuming a 2% interest rate, this would represent a repayment of €4.2 billion per year (perhaps less if the dollar depreciates), for a total borrowing cost of around €15 billion.

How could these billion euros be financed?

How could these €4.2 billion be financed? It would be possible, for example, to channel some of the revenues collected from the carbon border adjustment mechanism to this program, or from new budget allocations. Everyone would benefit: the climate, the countries concerned and their people, as well as companies from countries contributing to the fund. These firms would benefit from large investment and growth opportunities.

The EU could easily have the capacity to do this!

Gains would be tremendous. Assuming a $150/ton CO_2 price, and a 2.5 Gt annual carbon saving once the 500 GW mission is achieved, the gain for the planet is about $375 million per year, or $3.75 trillion assuming the programme would shorten the operation of these plants by 10 years. The net gain would thus amount to roughly $2 trillion, which does not include all the multiplier effects from the equivalent investments in alternative low carbon solutions, and the huge investments opportunities for the private sector.

The G7 should take this discussion forward and mandate the IEA, International Renewable Energy Agency (IRENA), World Bank, Asian development bank, European Investment Bank and Inter-American development bank, to lay out a more concrete proposal, and road map, in order to explore this potential further.

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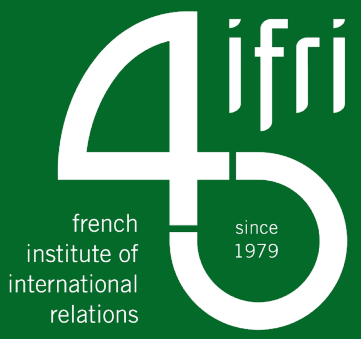

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