SOUTH ASIA

Ripe for Closure:
Accelerating the energy transition and saving money by reducing excess fossil fuel capacity

October 2021

CREA Centre for Research on Energy and Clean Air

TransitionZero

About the Authors

The Centre for Research on Energy and Clean Air is an independent research organisation focused on revealing the trends, causes, and health impacts and the solutions to air pollution.

CREA uses scientific data, research and evidence to support the efforts of governments, companies and campaigning organizations worldwide in their efforts to move towards clean energy and clean air. We believe that effective research and communication are the key to successful policies, investment decisions and advocacy efforts. CREA was founded in December 2019 in Helsinki, Finland and has staff in several Asian and European countries. For more information: energyandcleanair.org

TransitionZero combines financial and industry expertise with technology to help power a clear and timely transition to zero carbon in the power and heavy industry sectors. Using satellite imagery, machine learning and financial modelling, we gather real-time insights into the economic vulnerability of fossil fuel assets. We give key decision-makers the solutions they need to reach their zero-carbon targets.

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Contents

01 Executive Summary

In this report, we estimate excess operating fossil fuel-fired electricity capacity and its implications for future electricity costs and the ongoing energy transition. The purpose of this report is to contribute to the identification and genesis of fossil fuel overcapacity, whose retirement could yield savings for energy consumers without compromising the security of supply.

Specifically, the report found:

- **75 Gigawatts (GW) of excess fossil fuel capacity in India, Pakistan, and Bangladesh.**[1] Fossil fuel overcapacity was calculated by subtracting the planning reserve – which is the net non-fossil firm capacity and variable renewable capacity – from the total installed capacity of coal, gas and oil in each country.[2] India accounts for the largest excess capacity in absolute terms. However, with approximately 28% of installed fossil fuel capacity in Bangladesh and growing overcapacity in Pakistan, all three countries are building fossil fuels at a rate that threatens to lock in these carbon-intensive technologies to the detriment of their climate, environment and human health responsibilities and renewable sector development.
- **A paradox of overcapacity is taking place, where despite adequate or excessive installed generation capacity, power outages or rationing occur frequently and with great cost to consumers.** This is a major issue brought about by unplanned outages of generators, inefficient distribution companies (DISCOMs), and inefficiencies in systems planning that cannot be addressed by capacity additions alone. Underperformance of generation assets is particularly acute in countries where the DISCOMs and generators are shielded from responsibility when such events occur, or where the generators benefit from capacity payments regardless of whether they are available to service demand.

There is a combination of different options as to how overcapacity can be addressed to align the sector to a better pathway while ensuring economic, environmental and climate change factors that the countries face are considered in such transitions. This report recommends that the way forward prioritize the following:

- Setting concrete timelines for a phase retirement of excess fossil fuel-based generating capacity, especially in countries with a significant number of old coal power plants.
- No new investments in fossil fuels and reevaluating fossil fuel based capacity which is under construction or is proposed, this capacity should be replaced by renewable energy to fuel the growth in future electricity demand.
- Providing public data on long-term power purchase agreements, and reevaluating fossil fuel projects that are subject to power purchase agreement (PPA) renewals.
- Improving the grid management and system planning to ensure efficient utilization of renewable energy capacity and operation of the national grid.

[1] Modelled countries include: Bangladesh, India, Pakistan, Sri Lanka.
[2] See page 8 of the report for an overview of the methodology. A detailed account of the methodology and source material is outlined in the Methods & Materials section of this report.

02 Introduction

As demand for electricity grows in Asia amidst the urgent call for climate action, realignment of investments and policies away from fossil fuel technology and infrastructure is vital in meeting the temperature goal in the Paris Agreement.[3] According to the IEA, a global pathway to net-zero emissions by 2050 requires no new investments in coal capacity by 2021, with all unabated coal generation being retired or retrofitted by no later than 2040.[4]

Despite the urgency of the problem and the decline in renewable energy (RE) costs, fossil fuels accounted for almost two-thirds of global electricity generation in 2020,[5] and half of global greenhouse gas emissions in 2018.[6] This year, global energy demand is expected to rebound above 2019 levels, with a significant portion of electricity demand coming from major emerging economies that remain highly dependent on coal.[7] Moreover, according to Global Energy Monitor (GEM), there are still around 500 GW of coal under construction or in various stages of planning globally. Much of this capacity is planned in Asia, raising concerns that countries may lock in on increasingly uneconomic fossil fuels. In South Asia, countries like India, Bangladesh and Pakistan have almost 240 GW of installed coal-fired capacity. They also account for 14% of coal plants that are currently under construction or are planned globally, with approximately 42 GW already in the construction phase.[8]

As zero-carbon capacity has been operationalised, significant amounts of fossil fuel generation assets have entered technical overcapacity — or capacity that is no longer needed for a system to operate reliably and cost-efficiently in order to meet demand. While a buffer of capacity will always be needed to ensure security of supply during unexpected outages, excess overcapacity has negative economic consequences. From a systems perspective, overcapacity can result in stranded assets.[9] This is especially true in the electricity sector, where large infrastructure investments are long-life assets. For instance, coal-fired power plants have useful lives of 30 to 40 years.

Overcapacity develops principally as a consequence of overestimating future demand, failing to retire capacity or recalibrate the pace of additional construction when electricity demand falls, and market and infrastructure barriers that prevent full utilization of existing capacity. In electricity systems planning, capacity investment decisions are based on ensuring sufficient firm or dispatchable capacity to meet demand every day, while maintaining a planning reserve capacity for unexpected outages. Historically, this capacity has been met by fossil fuels, but unfettered construction of fossil fuel capacity without retirements, due to lack of price discovery, has made overcapacity a systems planning and infrastructure investment issue with huge implications in a

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[3] The Paris Agreement is an international treaty on climate change. It was adopted by 196 countries at COP 21 in Paris, on 12 December 2015 and entered into force on 4 November 2016. Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels.
[4] International Energy Agency (IEA), 2021
[5] BP Statistical Review of World Energy, 2020
[6] IEA, 2021
[7] IEA Global Energy Review, 2021
[8] Global Coal Plant Tracker, 2021 and World Electric Power Plant, 2021
[9] According to Carbon Tracker (2017), stranded assets are those assets that at some time prior to the end of their economic life are no longer able to earn an economic return, as a result of changes associated with the transition to a zero-carbon economy.

carbon-sensitive world. The growing emphasis on energy efficiency, demand response and zero-carbon generation technologies will only exacerbate this issue if excess capacity remains in operation and construction of fossil fuels continues unfettered.

For instance, India as a country has moved from a power deficit to power surplus geography as acknowledged by Mr. R. K. Singh, Minister of Power,[10] The excess power surplus situation is not always a good thing and is a consequence of the multiple factors mentioned above resulting in stranded assets[11], which the government has not been able to resolve over past years. Among others, one of the prime reasons for this overcapacity development in India is the rampant construction of new coal-based power plants following an overestimated power requirement by the Government of India under Electric Power Survey reports (EPS18 & EPS 19). Both EPS 18 and EPS 19 have over projected the power requirement for the country leading to misplaced generation choices and a coal boom exacerbating the amount of excess fossil fuel resulting in overcapacity[12].

Furthermore, on an oversupplied grid, there is little incentive or accountability for generators and system operators to ensure that plants operate reliably and responsively. This can lead to a large amount of unplanned outages, or plants being unwilling to generate when fuel prices are high, increasing the risk of electricity shortages or rationing. Communities in India, Bangladesh and Pakistan have all experienced electricity cuts for several hours per day, which can occur by default for most consumers, even as the capacity exists to keep the lights on. This may look like a paradox, but it is not uncommon for oversupplied grids to be unreliable. In South Asia, poor financial performance or profitability of power generation and distribution utilities, as well as slower and insufficient upgrades to the transmission infrastructure are the leading causes.

Governments like Bangladesh recognize the threat of additional coal build; in 2021, they declared the cancellation of 10 major coal plants, stating that delays in development and tapering demand growth, the need to be responsive as a global leader given the country's vulnerability to climate impacts, and the substantial environmental pollution from existing plants as the primary drivers.

Overcapacity has capital, operating and opportunity costs. New investments in coal capacity are still being made, despite being unnecessary to maintain security of supply.[13] Operating coal capacity incurs fixed operating costs (FOM), which do not vary with output.[14] Capital sunk in building new coal, and FOM costs from keeping capacity online also has an opportunity cost, as this capital could be spent on zero carbon technologies.[15]

In regulated electricity markets like those in South Asia, investments are made through power purchase agreements (PPAs). Conventional fossil fuel generators are often shielded from market forces and receive fixed capacity charges/payments regardless of whether or not plants are utilised. Such payment policies make overcapacity a cost borne by consumers and can raise the overall cost of electricity.[16]

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[10] Financial Express, January 03, 2021
[11] The Hindu, December 25, 2021
[12] Myllyvirta and Dahiya. 2019
[13] According to Global Energy Monitoring, there are approximately 42 GW of coal capacity under construction, and 35 GW planned in Bangladesh, India, and Pakistan as of July 2021.
[14] FOM costs are those incurred at a power plant which do not vary with generation. FOM costs typically include routine labor, materials and contract services and administrative and general expenses.
[15] According to the International Energy Agency's World Energy Outlook, solar is the cheapest form of energy.
[16] Moret S. et al, 2020

In this report, we estimate the amount of excess fossil fuel capacity in India, Bangladesh, and Pakistan, and the corresponding annual cost of maintaining such capacity at the expense of consumers and the energy transition.

Fossil fuel capacity in these three countries accounted for 62% of installed electricity capacity in 2021. Identifying the current state of excess fossil fuel capacity can inform system-level planning processes in each country to ensure the proper allocation of financial resources that enables diversification of generation sources away from fossil fuel and overall system efficiency. Identifying the cost of retaining assets online, despite those assets being underutilized and unneeded, can help policymakers plan for a least-cost electricity system. In doing so, policymakers can increase economic competitiveness and meet wider development priorities by providing consumers with access to the cheapest electricity possible.

03 Methodology

For this report, we use a methodology from electricity planning systems that plan for peak load to estimate the amount of fossil fuel overcapacity. Since COVID-19 disrupted demand and operations in the electricity sector, we use 2019-2021 datasets for peak demand, generation and installed capacity per fuel, which was collected for each country.[17] This data was then used to estimate fossil fuel overcapacity and their associated costs based on the following steps.

1. **Planning reserve.** On the demand side, a planning reserve — or the required capacity at which the electricity system can operate safely during peak demand — was calculated by applying a factor of 1.15 to peak demand in 2019-2021 (January 2019 - July 2021) to obtain the required total firm capacity that would have been needed to service peak demand and operate the electricity system without compromising security of supply.
2. **Available firm capacity.** Available firm capacity is the capacity of a specific fuel type that is most likely to be used to service peak demand. This was obtained by dividing the realized generation during peak demand by total installed capacity for each specific resource to account for available supply. Realized generation per source is obtained by multiplying the adequacy ratio (%) by the installed capacity (MW) of the specific fuel type. The adequacy ratio (AR)[18] is the percentage of firm capacity (MW) of a specific fuel that can be counted on in the electricity system during peak demand.
3. **Planning reserve met by fossil fuels.** The calculated available firm capacity of non-fossil electricity sources (nuclear, hydro, wind, solar, biomass, geothermal and import capacity) is then subtracted from the planning reserve to get the remaining capacity amount that would need to be met by fossil fuel capacity.
4. **Fossil fuel overcapacity.** The fossil fuel overcapacity was obtained by subtracting the remaining planning reserve (i.e. less non-fossil firm capacity and variable renewable capacity) from the total installed capacity of coal, gas and oil in the country. In most of these situations, overcapacity is a result of inflexible coal.
5. **Cost of overcapacity**. The fixed operation and maintenance (FOM) costs of the fossil fuel overcapacity are estimated based on publicly available sources.

The findings in the report follow a systems-level approach and do not include analysis of the spatial and temporal complexities of the individual grids for each country included in the report. Furthermore, the cost burden excludes other costs that may drive the overall cost of overcapacity even higher, including debt repayments and depreciation most significantly. A detailed account of the methodology and source material is outlined in the Methods & Materials section of this report.

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[17] We use public and commercial datasets, including: IRENA, ENTSO-E, GEM, and S&P Global Platts, as well as official public reports by country operators.

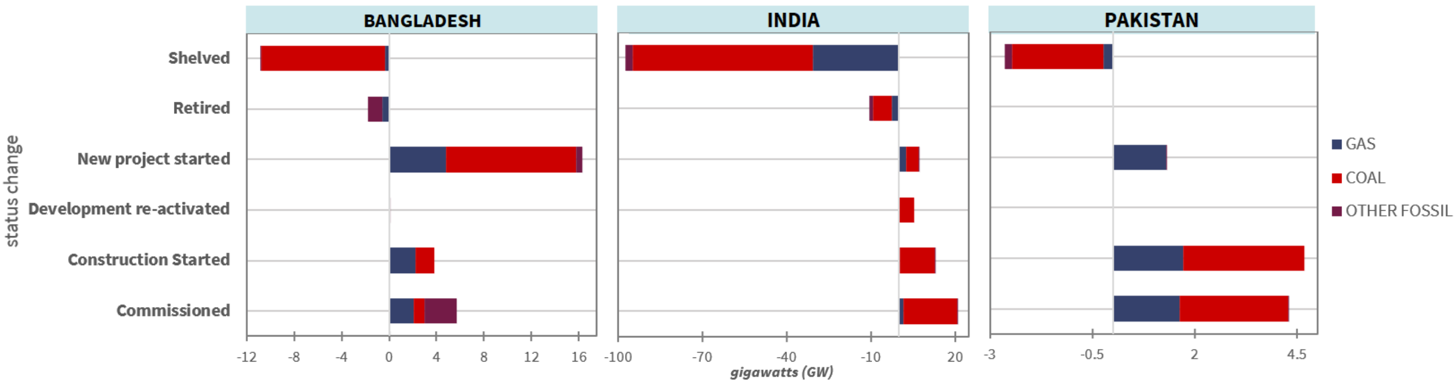
[18] Adequacy Ratios (ARs) are the result of dividing the realized electricity generation of a given fuel type during peak demand by the total installed capacity of the respective fuel. In cases where this is not available for a particular country, average ARs from neighbouring countries have been used, i.e., India the ARs of fossil fuel capacity is assumed to be 1.

04 Saving on Excess Capacity

Our analysis found approximately 75 GW — or 27% of the total excess fossil fuel capacity in the modelled countries in 2021— can be considered overcapacity in South Asia. The huge amount of overcapacity found in the study is a result of excessive investment in coal development, as construction has far outpaced actual demand growth within countries. Together, India, Bangladesh and Pakistan commissioned over 30 GW of coal, oil and gas capacity between March 2018 and 2021 (*Figure 1*), despite already massive fossil fuel construction that has resulted in low utilization of these capital intensive projects and saddled taxpayers with unnecessary costs.

This degree of overcapacity indicates that projects fueled by carbon-intensive sources have been allocated financing regardless of whether or not they are necessary to maintain energy security and meet the needs of consumers, even during the highest electricity demand peaks of the year. Expansion in the supply of clean electricity or contracting overall electricity demand also results in redundant fossil fuel generators, who are protected by inefficient power systems and markets at the expense of electricity consumers.

Figure 1: 123 GW of fossil fuel projects have been shelved or retired since 2018, but many remain in the pipeline



An estimated $2.3 billion USD in fixed operating & maintenance costs is spent on keeping this capacity in operating condition despite no longer being necessary to meet peak demand.Fixed operating & maintenance (FOM) costs are incurred at a power plant and include: routine labor, materials and contract services, and administrative and general expenses.[19] Such costs do not vary with generation, which means that spending on these plants continues despite the fact that they are being increasingly utilized.

Considering the vast amount of existing under-utilized capacity, as well as ongoing investment in new capacity, investment and FOM costs of these fossil plants drain the resources of utilities and create a perverse incentive to protect the market share of fossil fuels. This means that the maintenance and expansion of fossil fuel capacity often happens at the expense of investments in zero-carbon technologies and grid improvements.[20]

[19] There are several costs associated with running power plants. These costs include: fuel, variable operations and maintenance (VOM) costs, fixed operations and maintenance (FOM) costs, annual capital additions and costs associated with installing and operating control technologies to meet environmental regulations.
[20] Energy Information Administration (EIA), 2020A

The region has made considerable progress in reducing future fossil fuel capacity, as a large number of projects were shelved or cancelled in recent years (*Figure 1*). With over 42GW of additional fossil fuel capacity still under construction and another 34.8 GW planned in pre-construction stage,[21] India, Pakistan and Bangladesh are not only in danger of paying for more overcapacity, but also of paying for a significant amount of stranded assets that would hamper progress made on climate and environment goals.

The implications and solutions of overcapacity are discussed for each country in the subsequent section of this report.

COST OF RETROFITS TO MEET STRICTER ENVIRONMENTAL STANDARDS

Countries such as India will need substantial investments to retrofit old and high-pollution coal plants to be able to meet the emissions limits prescribed by the government to control air pollution and safeguard public health. With cleaner alternative options for added capacity, retrofitting overcapacity coal plants is a poor investment decision, shifting necessary capital investments from renewable technologies and locking in coal for many years. Various estimates pinned the cost of retrofitting the existing coal fleet in India to the tune of USD ~10 to 12 billion.[22,23] Approximately 43 GW of coal plants in India are due for, or under consideration for retirement (5 GW of the initially identified 48 GW are already retired over past 3 years) in the National electricity policy 2018.[24] Despite approaching retirement dates, many of these plants have been identified as potential retrofitting projects under the phasing plan for retrofits to meet the new emission standards for SO_2 control.

Based on the above estimates and analysis in this study, retiring overcapacity of about 82 GW of coal-based power plants in India would avoid additional investments in retrofits to keep unneeded plants open if this capacity is retired in a phased manner. Retirement savings could amount to approximately USD 5 to 6 billion in capital expenditure, on top of the savings on FOM costs that would have continued with retrofits instead of retirements, as estimated in the current study.

In Bangladesh and Pakistan, substantial coal-fired capacity has been built under very lax emission standards that allows plants to emit dangerous amounts of pollution, which contributes not only to air quality in host countries but also across the region. Retrofitting such plants with “best-available” emission controls technology will be necessary in protecting public health, reducing associated cost, and ensuring polluters accountability in the short-term.

[21] GCPT and Platts database, 2021
[22] International Institute for Sustainable Development (IISD), 2019
[23] Centre for Science and Environment (CSE), 2017
[24] Central Electricity Authority (CEA), 2018

05 Breakdown by Country

We analyzed the 3 countries in South Asia individually to get the amount of installed fossil fuel-fired capacity estimated to be redundant in 2021. The factors contributing to the build-up in excess capacity and the unique implications for each individual electricity market are explained further in this section.

We assessed the amount of generating capacity available to meet electricity peak loads (highest level of demand), including a planning margin that allows for some power plants or transmission lines being unavailable at the time of the peak. Each generating technology was assigned an adequacy ratio that accounts for the percentage of capacity that can be relied on, accounting for the variable nature of wind and solar generation in particular (see the methodology section for details).

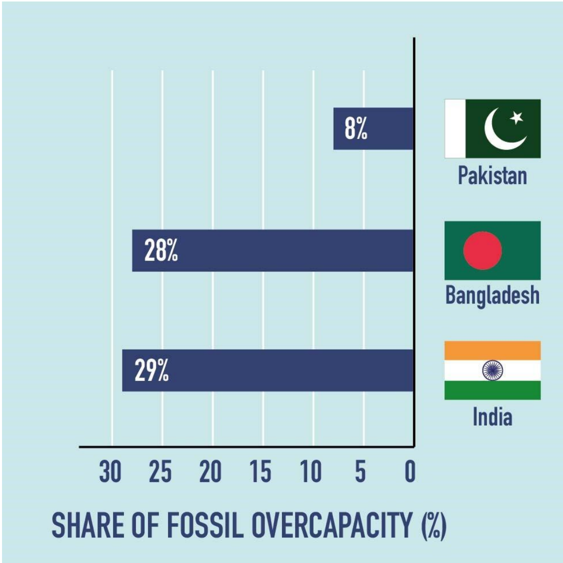


Figure 2: Share of fossil overcapacity in South Asian countries in 2021

Source: CREA & TransitionZero calculations

Bangladesh

In Bangladesh, around 28% (5.7 GW) of fossil fuel capacity can be classified as overcapacity in 2021. Fossil fuels account for more than 98% of the installed capacity in the country; mostly from oil and gas. This highly carbon-intensive sector also poses great health risk to the local population due to higher exposure to air pollution from fossil-fuel plants.

Between March 2018 and 2021, Bangladesh commissioned a total of 925 MW of coal, 2040 MW of gas, and 2745 MW of other fossil fuels like oil, which far outpaces the actual demand for electricity. In 2019-20, overall electricity capacity utilization was just 40%, though new coal-fired power plants were operating at a 65% capacity factor.[25] Despite dismal utilization of fossil fuel capacity and increasing pollution levels, approximately 18 GW of additional oil, gas and coal capacity is under construction or expected to be contracted for connection by 2025. Only 5.5GW is scheduled for retirement, implying a 60% increase in the country's total generating capacity and increasing the climatic and environmental threat that the country faces. The capacity additions are slated to come almost entirely from fossil fuels, with the exception of a proposed 1.2 GW nuclear power unit.[26]

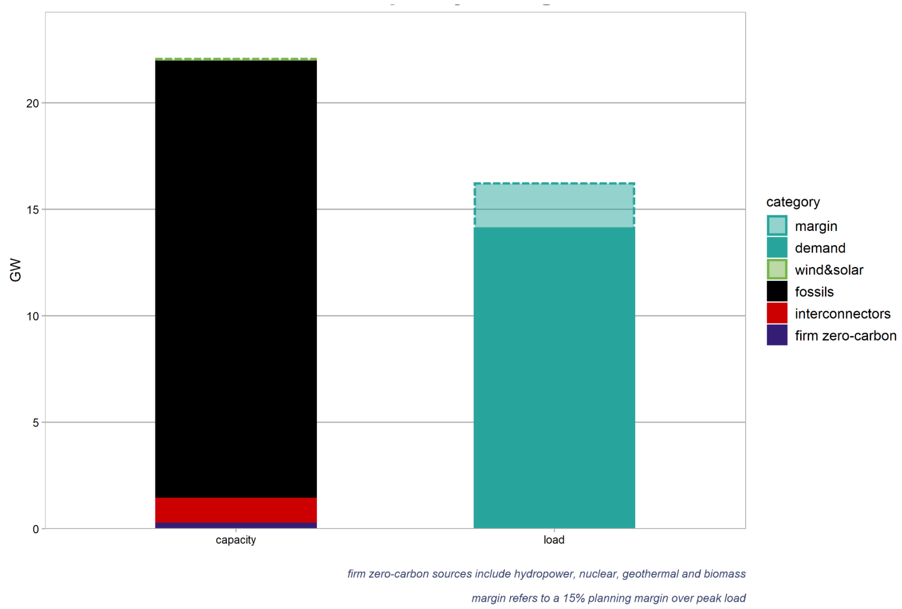
Bangladesh is one of the most climate-vulnerable countries in the world. It currently holds the presidency of the 48-nation Climate Vulnerable Forum and V20 Group of finance ministers, where promoting all efforts towards urgently reinforcing climate and economic resilience will be key. Due to the increasing difficulty in financing fossil fuel proposals and in growing recognition of the risk of

[25] IEEFA, 2021
[26] Bangladesh Power Development Board, 2020

emissions to planetary and human health, the Bangladesh government has declared the cancellation of 10 proposed coal power expansions.[27] But the remaining fossil fuel projects that are still under consideration for development threaten the country's progress away from fossil fuels.

Our findings show that given the 5.7 GW of excess capacity comes from oil-fired capacity in the country's electricity mix. Approximately $153.4 million USD (13.1 billion Bangladeshi Taka) in fixed operations and maintenance (FOM) costs are spent annually to keep this excess capacity in operational condition, regardless of whether they are used. Because oil-fired power plants are extremely expensive to operate, they are less likely to be deployed to service peak demand, increasing electricity cost burden for consumers. Such expenses should instead be reallocated towards cleaner generation sources and climate-proofing of the grid. Bangladesh has a high potential for wind and solar energy resources that it has yet to capitalize on with negligible renewable energy installed till now. Furthermore, excessive amounts of base load-type generation sources affect the flexibility and reliability of Bangladesh's electricity grid. Cancellations of proposed fossil fuel power capacity should be prioritized as such projects could result in stranded capacity, given the issue of surplus capacity existing in the present day.

Figure 3: Peak loads vs. installed capacity in Bangladesh, 2021



A new Power System Master Plan (PSMP) was scheduled for release in 2021 but has since been delayed for revision.[28] Bangladesh has an opportunity to address pricing, pollution and overcapacity issues plaguing the electricity sector due to overreliance on costly fossil fuel, much of which has been built in just the last decade despite the emergence and rapidly falling cost of more sustainable generation sources like wind and solar. Large-scale renewable energy projects are already cost-competitive with new coal plants. In 2019, the country's second utility-scale solar plant was set to come online with a reported tariff of $65 USD/MWh versus the estimated $99 USD/MWh tariff for the Rampal coal-fired power plant after tax, interest, and subsidies; without government subsidies, this further increases to $120 USD/MWh.[29]

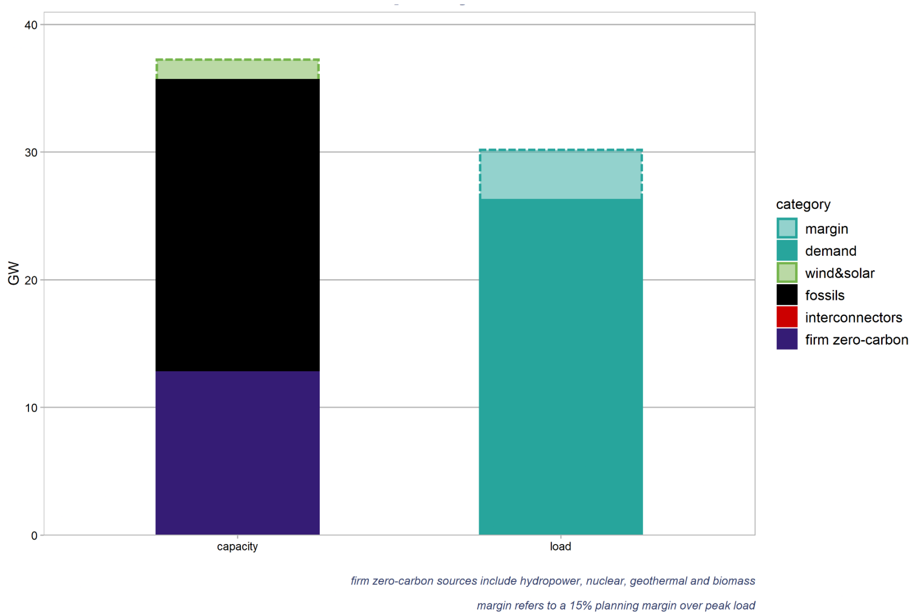
[27] Climate Home News, 2021B
[28] Dhaka Tribune, 2021
[29] IEEFA, 2019

With the recent cancellations of coal and the existing excess fossil fuel capacity, it will be vital that electricity growth be met by renewables, instead of replacing planned coal with another fossil fuel that will not only increase emissions from the electricity sector and do little to protect the natural environment, but which may also warrant expensive fossil fuel imports in the future.

Pakistan

The estimated share of overcapacity in Pakistan is about 8%, or 1.9 GW of fossil fuel capacity in operation in 2021. The country has been dealing with a huge burden of expensive electricity generation, which has been caused in part by expensive power purchase agreements with coal-based power plants by the government. In 2021, over60% of the country's installed capacity was fossil fuel; in the last 3 years, the amount of fossil fuels commissioned was equivalent to 5.7 GW versus just 3.5 GW of commissioned non-fossil capacity, mostly from hydro electricity. Recently, the government stated that it "will not have any more power based on coal," but expressed intentions to use its domestic coal reserves to produce energy via coal-to-liquids and coal-to-gas processes. This move to convert coal to gas or liquid would only add to the sector's financial burden[30] and prolong dependence on import fuels.[31]

Figure 4: Peak loads vs. installed capacity in Pakistan, 2021



In the fiscal year 2019-20, the overall utilization of Pakistan's thermal power generation fleet dropped to just 37%, which shows low utilization of coal, gas and oil-based power, exacerbated by increasing fuel costs.[32] By design, fixed cost charges in Pakistan's electricity grid are passed on to consumers regardless of the utilization of these plants. The country spends $42 million USD (Rs 7.3 million PKR) annually to maintain the surplus capacity of fossil power plants in FOM costs . With over 4 GW of coal-fired projects planned and 3 GW in construction, excess fossil fuel capacity could increase if not tackled right away. Investments in transmission and distribution system

[30] The Wire, 2021
[31] Climate Ambition Summit, 2020
[32] Institute for Energy Economics and Financial Analysis (IEEFA), 2020

improvements and more focus on clean and affordable renewables would aid in escaping the debt trap that has occurred due to high capacity charges paid to coal-based power plants, as well as aid in the pursuit of a low-carbon energy pathway for a country that is facing financial crunch and has to improve lifestyles and energy consumption for its citizens.

India

India's installed electricity generation capacity has more than doubled over the past decade with annual growth of approximately 8%, and coal-based capacity experiencing similar growth over the same period, though the capacity addition for coal has slowed over the last three years. Alongside this, electricity demand grew more slowly by approximately 5.5% annually, indicating that capacity expansion ran ahead of demand. This addition of huge capacity over the past decade led to an overcapacity buildup in India's electricity sector, which was reflected in historically low operations of coal-based power plants/low plant load factors (PLFs) and the creation of non-performing-assets (NPAs) with the gap increasing further over the past five to seven years .[33]

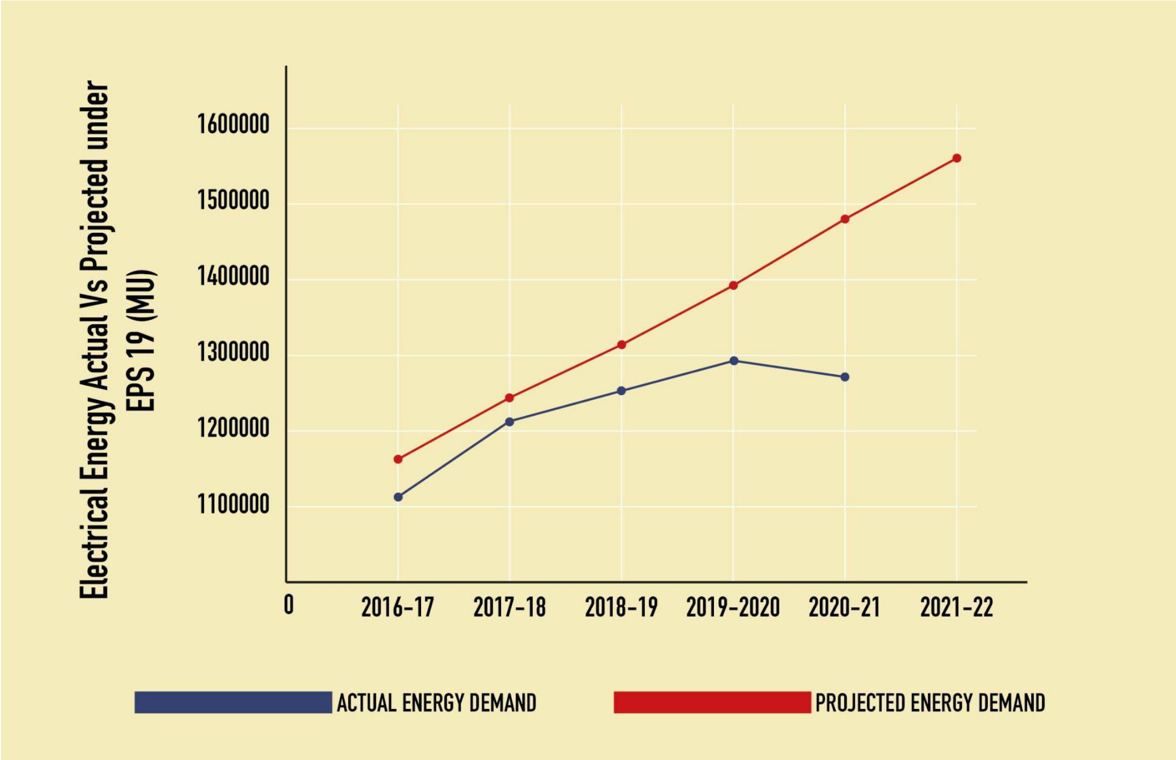
Most of the private sector coal-based power plants built during the past decade have failed to complete their construction due to the drying up of financing, difficulties in obtaining sufficient coal supply to meet mass build, or failure to sign power purchase agreements; the trend has also started plaguing the coal plants owned by the state and central sector. Even if all such hurdles are passed, coal assets have become economically challenging to build and operate. On the other hand, India's wind and solar generation has grown 2.5-fold since 2015 and coal's contribution to electricity generation in India fell for the second straight year in 2020, marking a departure from decades of growth in coal-fired power. Still, the highly polluting fuel accounts for nearly three-fourths of India's annual power output.

Under the electric power survey 2019 (EPS 19), India revised its power demand forecast for future years in an attempt to correct the over-projections in demand under EPS 18, which was predicted to grow more than 20% higher than actual demand in 2019–20. However, the projected growth in electricity demand under EPS 19 was still 14% higher than actual demand in terms of annual electrical energy demand (MU),[34] and approximately 11% higher in terms of peak demand projections (MW) for the year 2020-21. Even in the years before the COVID-19 crisis, actual electrical energy demand was around 6–8% below the predicted levels, and 2–3% lower for peak demand. The gap widens as we move along the years for prediction of the demand under EPS, a similar trend observed in earlier EPS18.

Figure 5: Gap between projected electrical energy demand (EPS 19) Vs actual electrical energy demand in India

[33] The Economic Times, 2018

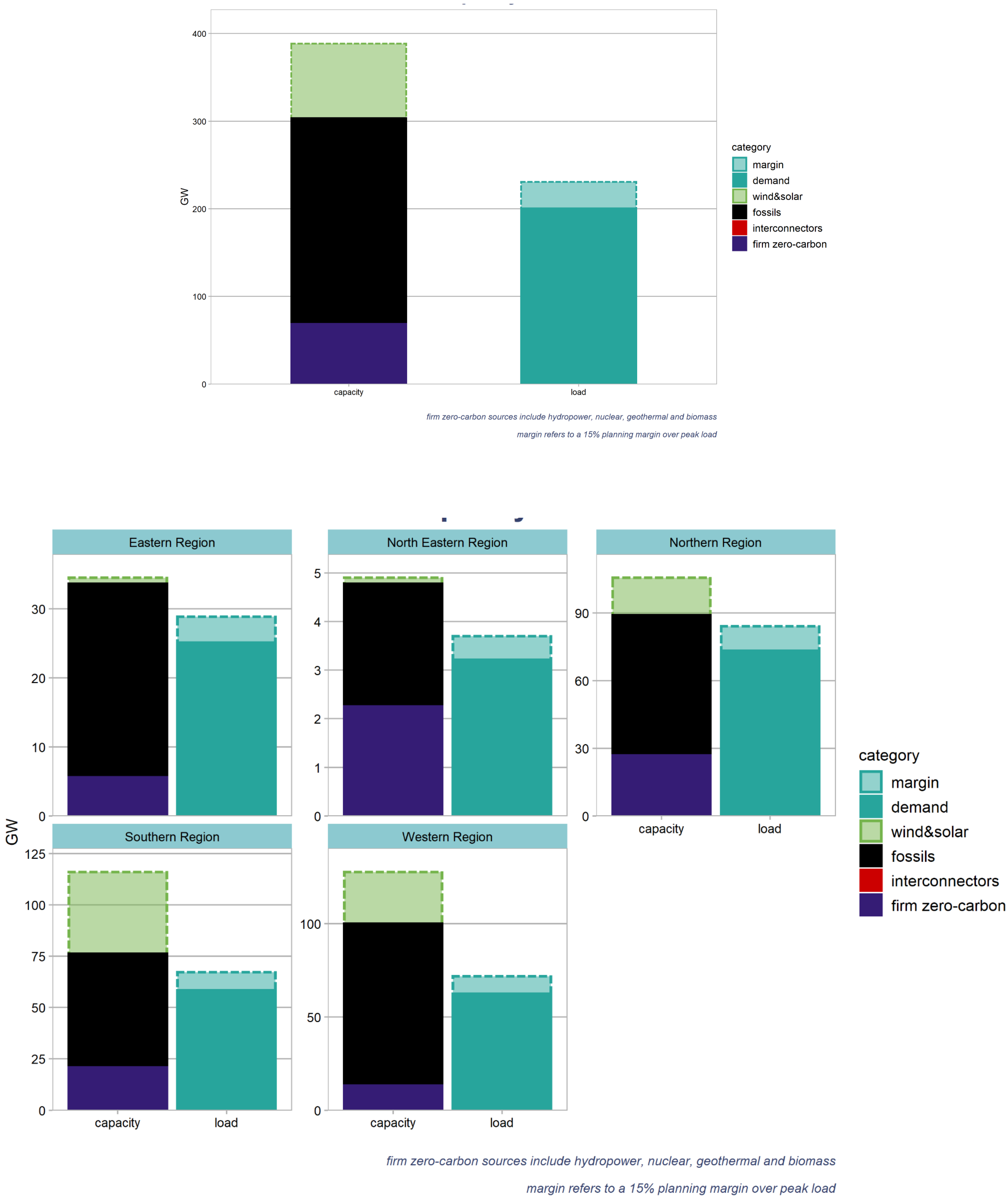
[34] MU, or 'Million Unit', is commonly used in India for energy demand and is equivalent to gigawatt-hours (GWh).



Our research found that an estimated 29% of the installed fossil fuel capacity in India is in excess of what is required to meet its 2021 peak electricity demand (7th July 2021). This is equivalent to 67.6 GW of overcapacity — all coming from coal-based power plants. A breakdown of excess capacity in the five regional grids, which broadly correspond with the five regions of the country, shows that overcapacity is a shared issue. The western region has the highest share of overcapacity out of total fossil fuel installed capacity at 33%, followed by the southern region (19%), the northeastern region (13%), the eastern region (11%) while the north region didn't have any estimated overcapacity.

With India's plan to expand renewable energy capacity from 95 GW in 2021 to 450 GW by 2030 and capitalize on the competitive prices of RE plus storage, the requirement of coal-based electricity to retain the security of supply is going to diminish further. This highlights an urgent need to rationalize the existing electricity generation capacity by shutting down the excess and polluting old coal-based capacity and stalling new coal expansions in the country. Immediate savings in FOM costs from the retirement of excess coal is estimated at $2.1 billion USD per year (₹ 157.8 billion INR).

Figure 6: Peak loads vs. installed capacity across grid regions in India, 2021



Source: CREA & TransitionZero calculations

06 Recommendations

The key objective of energy planning is to keep the lights on in an economically efficient way while delivering rapid emissions reductions. Amidst the growing threat of climate change, fossil fuel development runs counter to sustainable economic development. This report shows that many countries are protecting incumbent generators with high carbon and air pollutant emissions, even when their contribution is not needed to meet current or future power demand with adequate safety margins.

Given the enormous potential savings in maintenance costs and benefits to human and planetary health, phasing out excess fossil fuel capacity and ensuring that future demand is met by renewable energy by halting additional fossil fuel projects is a crucial first step in the energy transition. There is a combination of different options as to how this can be accomplished for each country. This includes but is not limited to:

- **Setting concrete timelines for a phased retirement of excess fossil fuel-based generating capacity, especially in countries with a significant number of old coal power plants.**

  Given the potential annual savings from retiring excess fossil capacity, India and Bangladesh should redesign phaseout plans to adopt an earlier retirement schedule, especially as the amount of excess fossil fuel capacity demonstrates that security of supply can be maintained without keeping ageing capacity on life support. Reductions in public health burdens and associated economic costs are unaccounted for in this study, but will increase potential savings and benefits that would stem from such retirements. Central Electricity Authority (CEA) prepared a list of 263 power plant units with total capacity of 48 GW which is planned to be retired by 2027 in India out of which only about 5 GW was retired by 2020 leaving a huge aged capacity still online for generation and adding to higher expenses and costs.

- **Setting transparent retirement guidelines and timelines for older and polluting fossil fuel power plants**.

  Due to the lack of firm guidelines or policy for retirement of fossil fuel plants, their operations continue beyond useful life resulting in risky operations leading to accidents,[35] as well as having a higher carbon and environmental pollution footprint. These countries should develop concrete guidelines on retirement of old coal/fossil fuel based power plants stipulating the procedure for a scientific and socially just retirement process.

- **Canceling all new fossil fuel power plants in the pipeline, and re-evaluating fossil fuel based capacity, and its share in the future energy mix.**

  There is a growing consensus that no additional fossil fuel capacity should be built in order to meet temperature goals under the Paris Agreement as well as to meet the future energy demands of countries analysed in the report. The future demand growth can be fueled by sustainable renewable energy options in a more economical way compared to fossil fuel

[35] Down To Earth, 2020

projects, therefore where capacity expansion is already committed, financiers, suppliers, and planners need to find solutions to convert projects into clean energy.

- **Provide public data on long-term power purchase agreements, and re-evaluate fossil fuel projects that are subject to power purchase agreement (PPA) renewals.**

  It is very important to have information on PPAs in the public domain so as to ensure that the researchers, general public and policy makers can be well informed on the need and benefits of rationalising the PPAs and a demand for concrete and efficient action is created through research and public scrutiny. Doing so can free utilities and distribution companies from huge capacity charges that would need to be paid to keep idle fossil fuel power plants in operating condition. Instead, finances can be utilized for efficiency improvements and procurement of cheaper renewable energy sources by the distribution companies.

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08 Appendix: Methods & Materials

The researchers employed a methodology derived from energy planning systems to estimate the megawatt amount of fossil fuel overcapacity in 23 countries — 3 of which are included in this regional report for Europe.

Because COVID-19 disrupted regular demand and operations in the power sector, the data from the beginning of 2019 till July 2021 were compiled from various public and commercial databases and used in the calculations for South Asia region i.e., India, Bangladesh and Pakistan (2021 saw higher demand compared to pandemic and pre-pandemic period). The three types of data collected for each of the countries were:

- *Peak demand* (MW) and the *time* of peak demand to the day and hour. Government data from the Ministry of Power or other equivalents in each country was collected from various public sources including annual, monthly reports and website information etc.
- *Historical Generation* data (MW) for each fuel source during peak demand was interpreted from the peak day source wise generation graphs for each made available by Power System Operation Corporation Limited (POSOCO), India and was assumed to be true for other two neighbours. Variable renewable energy categories included: offshore wind, onshore wind, solar photovoltaic, and concentrated solar power. Firm zero-carbon technologies include nuclear, hydro reservoir, hydro run-of-river, pumped hydro, biomass, and geothermal. Fossil fuels are gas, oil, coal, and combined heat and power (CHP).
- *Installed capacity per fuel source* and *import capacity* (MW) for 2021 as well as renewable energy capacity was based on official government reports. Data for gas, oil, and nuclear capacity was collected from S&P Global Platts (World Electric Power Plants Database). Data from the Global Energy Monitor (Global Coal Plant Tracker database) was used for coal. Data on interconnection was collected from publicly available sources.

Estimating the cost of overcapacity relies on the main assumption that any electricity system that has more installed and available firm capacity than the peak demand (MW) plus the appropriate planning margin can be considered as technical overcapacity.[36]

Furthermore, in a least-cost dispatch model, the most efficient and less costly plants are run to meet demand. The estimation of fossil overcapacity is based on observed merit orders of different technologies in India where coal, gas and oil are mid to peak merit technologies. Coal, gas and oil capacity enter the generation stack towards the middle and end of the merit order given priority to renewable energy and hydro projects.

Thus, the current method allows for the estimation of fossil fuel overcapacity. A more granular estimation per fossil fuel source requires additional modeling of marginal costs of each fossil fuel, which is beyond the scope of the current report. However, one can infer from marginal costs of electricity generation from different fossil fuel sources that most of the estimated overcapacity consists of coal, followed by fossil oil, and finally, gas.

In any electrical system dominated by coal power plants generation or with a significant share of coal generation, almost all the estimated overcapacity can be assigned to coal plants.[37]Older plants

[36] North American Electric Reliability Corporation (NERC), 2020.
[37]Carbon Tracker Initiative, 2018

that are being kept idle due to lack of demand and high costs of generation are the biggest contributors, and have higher fixed and variable operating costs. The implication for overcapacity is that systems with overcapacity from older plants are highly likely to be kept idle due to lack of demand. Yet, the FOM costs of these plants need to be paid for if one expects them to be operational.

Process of Calculating Overcapacity & FOM Costs

Share and amount of overcapacity per country

1. A planning reserve was calculated by applying a factor of 1.15 to peak demand to obtain the required total firm capacity that would have been required to service peak demand and operate the electricity system safely (i.e. cause no disruptions in supply).
2. Available firm capacity, which includes non-fossil electricity sources (nuclear, hydro, wind, solar, biomass, geothermal and import capacity), was assumed or calculated — where available — by dividing realized generation of each fuel during peak demand by total installed capacity. The result is then multiplied by the total installed capacity of each specific fuel source.
3. In order to obtain the planning reserve amount that needs to be fulfilled by fossil fuel capacity, the calculated available firm capacity of non-fossil electricity sources was subtracted from the planning reserve.
4. The fossil fuel overcapacity was estimated by subtracting the remaining planning reserve that needs to be fulfilled by fossil fuels from the total installed capacity of coal, gas and oil in the country.

Cost Estimation

The cost of overcapacity discussed in this report is represented by the FOM costs. FOM costs are those incurred at a power plant which do not vary with generation. According to the US EIA,[38] FOM typically includes routine labour, materials and contract services, and administrative and general expenses. The EIA states:

> "*Routine labor includes the regular maintenance of the equipment as recommended by the equipment manufacturers. This includes maintenance of pumps, compressors, transformers, instruments, controls, and valves. The power plant's typical design is such that routine labor activities do not require a plant outage. Materials and contract services include the materials associated with the routine labor as well as contracted services such as those covered under a long-term service agreement, which has recurring monthly payments. General and administrative expenses are operation expenses, which include leases, management salaries, and office utilities. For the hydro, solar, wind, and battery energy storage cases, all O&M costs are treated as fixed costs.*"

[38] EIA 2020a

The FOM costs are estimated based on the IEA's 2020 World Energy Outlook (WEO).[39] The IEA does not disaggregate variable operations and maintenance (VOM)[40] and FOM. For this reason, we estimate FOM based on a disaggregate of the IEA data. Specifically, we assume 90% of the "Annual O&M Costs'' in the IEA's 2020 WEO Power Generation Assumptions are FOM. The 90% estimate is aligned with a comprehensive global study undertaken by DIW Berlin.[41] The total cost of overcapacity at country level is calculated from asset level data at plant level and consolidated at country level. We assumed that the oldest plants in the stack are the ones accounting for the overcapacity estimates. Plant level estimates of overcapacity costs were obtained by multiplying the MW capacity by the FOM costs for the specific country and technology. Plant level data was aggregated to country level.

Table 1A: Fixed Operations & Maintenance Cost Assumptions

Entity	Fixed Operations & Maintenance (US$/MW) by Technology		
	Subcritical	Oil	
India	31500		
Pakistan		22500	
Bangladesh		22500	

Source: TransitionZero based on IEA and DIW Berlin

Accounting for Electricity Planning Issues

Electricity systems have two peculiar features that need to be addressed for the system to be managed safely and cost effectively. Firstly, generation must equal demand at any point in time. Secondly, enough firm capacity must exist in order to meet estimated peak demand and — on top of this — a reserve margin of firm capacity must be available in case of forecasting errors or unexpected unavailable capacity during peak demand.

The planning reserve margin ensures that the second feature of electricity systems is met, by providing insights on available capacity and required capacity to manage safely and cost efficient an electricity system. This stems from the Planning Reserve Margin (PRM) defined by The North American Electricity Reliability Corporation (NERC) as a measure of the available capacity to meet peak demand and to safely operate the electricity system. The PRM is a ratio of the difference between available firm generation capacity and peak demand as stated in the (1) formula:[42]

(1) $$PRM = \frac{(G - P)}{P}$$

where G stands for generation and P stands for peak demand.

[39] IEA, 2021

[40] VOM costs are generation-based costs that vary based on the amount of electrical generation at the power plant. According to the EIA (2020), these expenses include water consumption, waste and wastewater discharge, chemicals such as selective catalytic reduction ammonia, and consumables including lubricants and calibration gas.

[41] DIW Berlin, 2013

[42] Kahrl, 2016; NERC, 2019

As an analytical tool to assess the suitability of existing capacity in meeting peak demand, the planning reserve margin and the exact timing of peak demand has an impact on the type and total capacity of different fuel sources that service peak demand and beyond that the demand throughout the year. Its value should always be higher than 1, ranging between 1.1 and 1.2 depending on the characteristics of the electricity system and peak demand. NERC recommends a PRM of 1.15 for thermal based systems and 1.1 for hydro based systems. In the United States, the upper range of the PRM extends to 1.24 in some cases. For this report, PRM used is 1.15 due to the fact that most of the electricity systems analyzed are heavily reliant on thermal capacity. The planning reserve margin has a direct impact on system costs and the type of capacity chosen to fulfil electricity demand in a given country.

Adequacy Ratio Calculations & Assumptions

A set of assumptions for variable renewable energy adequacy ratios were found in earlier research on fossil fuel overcapacity.[43] However, these were deemed dated given advances in variable renewable technology, and increased knowledge in forecasting and integrating higher shares of variable renewable energy sources (VRES) in electricity systems.

To capture the worst case situation in terms of the residual gap between demand and VRE supply that needs to be met with dispatchable capacity, we looked at peak demand day for each month between January 2019 to July 2021 and looked at 15 minute demand data for that day, which later was also correlated to the generation curve for various sources to estimate the lowest generation by VRE on that day of highest demand for the month and the lowest generation and installed capacity at that moment for the source was used to arrive at capacity utilization factor (CUF) or AR for Solar, wind and hydro. The ARs such as those derived for India were applied for Bangladesh and Pakistan as well.

Although the generation from solar for India has been taken to be on highly conservative side where the peak demand was observed around 2 PM-3PM when the generation from solar would be around 60% but the AR applied in the study is 30% so as to cater to not just the peak demand but gradual buildup to the peak demand.

In line with previous work, an adequacy ratio of 100% was assumed for geothermal, coal, gas and oil in all countries.

Table 2A: Adequacy Ratios Values, 2021

	Offshore Wind	*Onshore Wind*	*Solar PV*	*CSP*	*Hydro Reservoir*	*Hydro (Run of river)*	*Pumped Hydro*	*Biomass*	*Geothermal*	*Coal*	*Gas*	*Oil*	*Nuclear*	*Inter-connectors*
India	—	*0.06*	*0.30*	---	*0.63*	*0.60*	---	*0.80*	--	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
Bangladesh	—	*0.06*	*0.30*	---	*0.63*	*0.60*	---	*0.80*	--	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
Pakistan	—	*0.06*	*0.30*	---	*0.63*	*0.60*	---	*0.80*	--	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*

Source: CREA & TZ estimates

Caveats

The focus on peak demand to estimate overcapacity can be scrutinized further under the premise that while peak demand is the most consequential event from a systems planning perspective,

[43] Kahrl, 2016

electricity systems with increasing shares of VRE have to plan for numerous, significant, and short-term declines in electricity generation capacity. These occurrences require flexibility foremost, such as battery storage and demand response. Coal-fired power plants have low flexibility and high start up costs, making them less suitable for contributing to system reliability.

Furthermore, there is growing acknowledgement that systems with high VRE penetration pose challenges that are different from ones faced by systems dominated by large, fossil fuel based power plants. This report employs a simplified framework to account for overcapacity in a power system based on methods developed to assess system risks and reliability in fossil fuel heavy power systems. This type of analysis serves the reliability needs of most systems that are based on large, dispatchable fossil fuel power plants; however, with the growing shares of renewables, updated tools for reliability assessments will be needed as a key feature of dangerous events associated with VRE — namely duration of ramp up or ramp downs — are not captured in more traditional assessments and tools. As recent reports establish,[44] modeling systems' reliability has to incorporate these events as the share of VRE increases in grids around the world. Finally, a more extensive probabilistic modeling based on weather over the years is required to effectively incorporate the changing patterns in climate, which affect weather events. This would strengthen the results presented in our simplified framework.

Lastly, while the FOM costs presented in this report are significant, they are only one part of the overcapacity costs. Another part of the overcapacity costs that is beyond the scope of this report are the depreciation costs and undepreciated value of coal plants that are technically overcapacity. Undepreciated coal power plants bear accounting losses from depreciation that is not offset by generation revenues. As coal power plants are phased out in a carbon constrained world, these costs will be increasingly scrutinized by policy makers in order to inform phase out schedules and compensation of early retirement where necessary.

[44] ESIG, 2021