In *the* Dark

Power Sector Challenges *in* Myanmar

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IN THE DARK:
POWER SECTOR CHALLENGES IN MYANMAR

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Preface and Acknowledgments

This report assesses underlying causes of the ongoing power sector crisis in Myanmar. It illustrates the implications on the near-future power supply using scenario-based analysis to understand the complexities related to the power sector performance, risks, and outlook.

The report was prepared by a team comprising Joonkyung Seong (Senior Energy Specialist), Myoe Myint (Senior Energy Specialist) and Sadig Aliyev (Program Leader for Infrastructure) under the guidance of Jie Tang (Practice Manager, Energy), Mariam J. Sherman (Country Director) and Ranjit J. Lamech (Regional Director, Infrastructure). The team appreciates valuable guidance received from peer reviewers Claudia Ines Vasquez Suarez (Lead Energy Specialist, Program Leader), Mitsunori Motohashi (Senior Energy Specialist) and Kim Alan Edwards (Senior Economist, Program Leader).

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Abbreviations and Acronyms

ASEAN	Association of Southeast Asian Nations
Bcf	Billion cubic feet
CNG	Compressed natural gas
ESE	Electric Supply Enterprise
GDP	Gross domestic product
GW	Gigawatt
kWh	Kilowatt hour
LNG	Liquid natural gas
MESC	Mandalay Electricity Supply Corporation
MMK	Myanmar kyat
MMscf/d	Million standard cubic feet per day
MOE	Ministry of Energy
MOEE	Ministry of Electricity and Energy
MOEP	Ministry of Electric Power
MW	Megawatt
NTL	Nighttime lights
PPA	Power purchase agreement
PV	Photovoltaic
US$	United States dollar
YESC	Yangon Electricity Supply Corporation

Executive Summary

Myanmar's power sector has been severely affected by the ongoing political turmoil. The power sector has been spiralling downward since 2021 with prolonged electricity blackouts throughout the country. Electricity generation has been declining, resulting in a widening power supply–demand gap. The repercussions of damaged power infrastructure due to conflict have impacted the stability of the whole transmission system. Major cities, including Yangon, Mandalay, and Nay Pyi Taw, are facing power outages while industrial zones across the country are bracing for crippling power cuts and surging fuel prices.

Increasing the power supply–demand gap is the major challenge to securing reliable electricity services in the country. Myanmar already faced power shortages in 2019, of up to approximately 300 megawatts (MW). The power supply–demand gap has widened since 2021. Generation capacity available for dispatch has been reduced by more than 2.5 gigawatts (GW), due to various factors, including the suspended operation of two large liquified natural gas (LNG)-to-power plants in Yangon, low precipitation and low water levels in hydropower reservoirs, and a supply shortage of domestic natural gas. Furthermore, more than 2 GW of planned natural gas-based power plants involving foreign direct investment are on hold. New hydropower and solar photovoltaic (PV) development continues but with slow progress. Domestic gas fields are projected for production decline and depletion over the coming years, and major multinational companies that were developing new offshore gas fields have left the country.

To maximize the total daily power supply, electricity generation was ramped up from hydropower plants since mid-2021 to compensate for lower electricity generation from gas-fired power plants. More water resources were utilized from the hydroelectric reservoirs during the rainy season. Consequently, there was a sharp drop-off in the amount of water available for electricity production and irrigation in January 2022. Four hydropower units had to be temporarily disabled for maintenance operations in mid-2022, including Myanmar's second biggest dam, Shweli-1. This further reduced available capacity and resulted in an acute electricity shortage during the dry season from January to May 2023.

Constrained transmission and distribution network capacity also contributes to electricity shortages. The electric grid network has been attacked and damaged amid ongoing conflict. The authorities claimed that the power grid has been attacked 229 times between February 2021 and April 2023. About 77 percent of existing power plants are within 10 kilometers of conflict-related fatalities. While numbers of conflict-related events on electricity infrastructure have been declining since the peak in late 2021 and early 2022, the grid network capacity remains vulnerable. Furthermore, transmission network development, including interconnection with neighboring countries for power imports, has not made much progress since 2021.

The power sector continues to be hit by financial losses. Several factors affect sector financial sustainability, including currency depreciation, increasing grid maintenance costs, and a decline in revenues. Having depreciated since 2021, the Myanmar kyat has pushed hard currency-linked power purchase prices upward from independent power producers. With damage to the grid network, maintenance costs have increased. Furthermore, the military takeover triggered a country-wide boycott of electricity bill payments. The unpaid portion of electricity revenue increased over time, reaching up to 45 percent in November 2021. While significant deficits are anticipated from the power sector, increasing revenue from natural gas exports to China and Thailand can contribute substantially to the financial position of the energy sector as a whole, including electricity and fuel.

There have been few advances in improving electrification, leaving over four million households without access to electricity. The prospects of achieving universal access to electricity by 2030 have dimmed. Between November 2020 and December 2021, the electrification rate at the household level increased from 57.9 percent to 61.6 percent, only 3.7 percent increase over a year, compared to average 6 percent per year between 2017-2020 at the household level. Petroleum fuel prices increased two to three times higher since 2021 due to supply shortages and currency depreciation. Such extremely high fuel prices put pressure on mini-grid operators and businesses, further reducing access. Distributed renewable energy is gaining more ground in meeting electricity demand, but supply chains and access to finance are impediments to further scale up.

The energy shortage is affecting all walks of life across the country. Power outages in Yangon have caused long queues at the compressed natural gas (CNG) filling stations. This has a direct impact on buses operated by the Yangon Bus Services and taxis, resulting in a shortage of public transport services for commuters. Healthcare workers cannot keep essential medication and test samples refrigerated. Most industry, factory, and commercial buildings use their own diesel generators for operations during power outages. These outages negatively impact the competitiveness of the low-margin garment industry that dominates the country's manufactured goods exports.

Myanmar's power sector will likely continue to experience significant challenges. To sustain the current level of power supply would require adding 300-500 MW every year until 2030. Scenario analysis on the power supply–demand gap illustrates that available generating capacity is projected to not meet the growing demand. The electricity supply–demand gap will be exacerbated with difficulties in mobilizing capital investment in power generation and upstream gas exploration. Keeping transmission and distribution networks up will also not be straightforward due to the constraints on financial and human resources. In the medium to long term, domestic gas depletion and difficulties in mobilizing investments in additional generation sources will likely drive the power sector to an even worse situation.

Many of the challenges in the power sector are structural, fundamental, and linked with political instability, conflict, and macroeconomic conditions. They cannot be easily fixed with short-term measures and require longer-term approaches and steady progress based on proper planning over the long-term. The analysis leads to the following conclusions on the outlook for the power sector:

- Gaps in power sector infrastructure are massive and cannot be addressed without improvements in the investment climate, which has deteriorated and is exacerbated by the ongoing political and economic crisis.
- Power imports, which also remain challenging under the current country situation, may help reduce the electricity demand-supply gap.
- Improving power sector financial viability and recovering customer confidence are critical for private sector capital mobilization to enhance the quality of electricity services.
- Distributed renewable energy solutions can help ease electricity shortages for the population but supply chain issues, access to finance constraints and limited awareness by customers are impediments to scale up.

I. Context: The Deepening Power Sector Crisis in Myanmar

Myanmar's power sector has been severely affected by political and macroeconomic instability since the February 2021 military takeover. Following the significant uncertainty and volatility that characterized much of 2022, economic conditions appear to have stabilized in the first half of 2023. The gross domestic product (GDP) is projected to increase by 3 percent over the year to September 2023, continuing the weak recovery in overall economic activity that began in 2022. The absence of a more pronounced rebound – with GDP still around 10 percent lower than in 2019 – is indicative of the persistent supply- and demand-side constraints on production.[1] At end 2022 to early 2023, almost half of Myanmar households reported a decrease in incomes over the past year, suggesting that a larger proportion of households were living below the poverty line relative to pre-Covid pandemic levels.

The power sector has been spiralling downward over the past two years with prolonged electricity blackouts and extreme load shedding[2] throughout the country. Major cities, including Yangon, Mandalay, and Nay Pyi Taw, are facing power outages while industrial zones across the country are bracing for crippling power cuts and surging fuel prices. Revenues from bill collecting have also declined because many customers withhold payments. Most international energy companies have pulled out of the market to mitigate reputational risks. No major new investment activity has been observed for energy infrastructure, which indicates the degree of challenges in the energy sector.

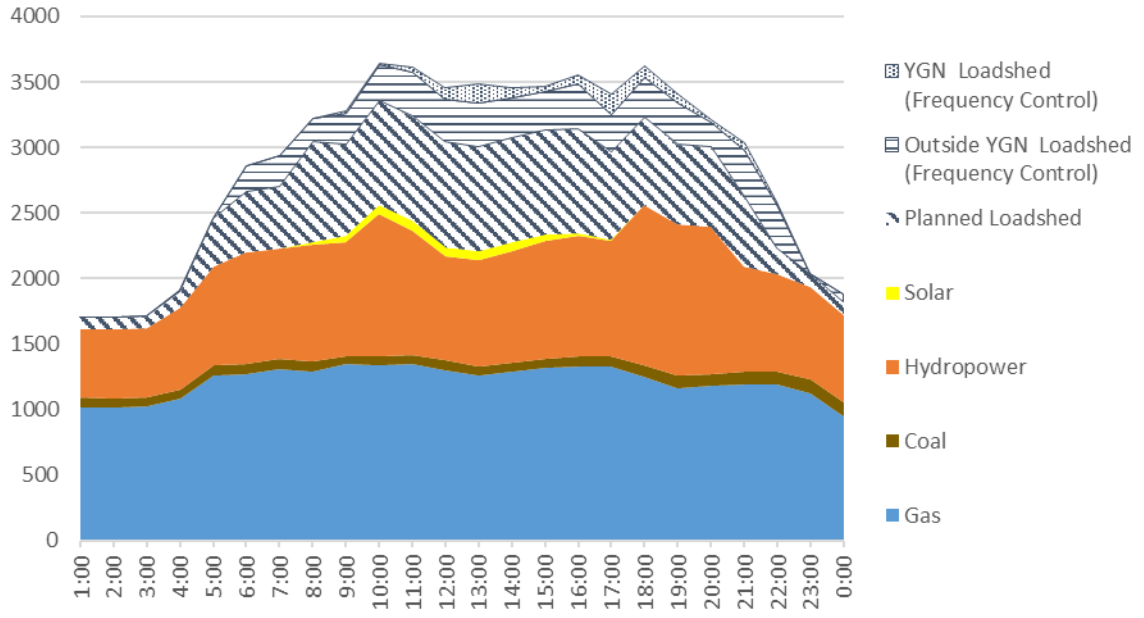
The acute electricity shortage worsens in the dry season (January-May) before monsoon rains start filling hydropower reservoirs. No additional capacity is expected to come online, and the authorities plan to ration electricity, including in Nay Pyi Taw and Yangon metropolitan areas. Although power blackouts, brownouts, and system breakdowns are not new to Myanmar, the scale of the power outages has significantly increased in the past two years. Most consumers experienced daily power cuts, with a mix of planned load shedding and unplanned system breakdowns. The authorities prioritized cities over rural areas and forced some factories to stop nighttime operations. Unplanned and prolonged power cuts became a major disruption for businesses.

When the demand for electricity nears available supply levels, load shedding has been continuously spread throughout a 24-hour period. On December 31, 2022, for example, 26 percent of total electricity demand in Yangon area went unserved (Figure 1). At 1:00 pm, load shedding represented 37 percent of electricity demand, including 800 megawatts (MW) of planned loadshedding, and 147 MW and 331 MW of unplanned frequency control in Yangon and outside Yangon, respectively. Traditionally, December is not a period of frequent power shortages as dam reservoirs have sufficient water levels and winter temperatures lower the need for air conditioning. The magnitude of load shedding gradually increased toward the end of 2022 (Figure 2).

[1] A Fragile Recovery, Myanmar Economic Monitor, June 2023, World Bank.

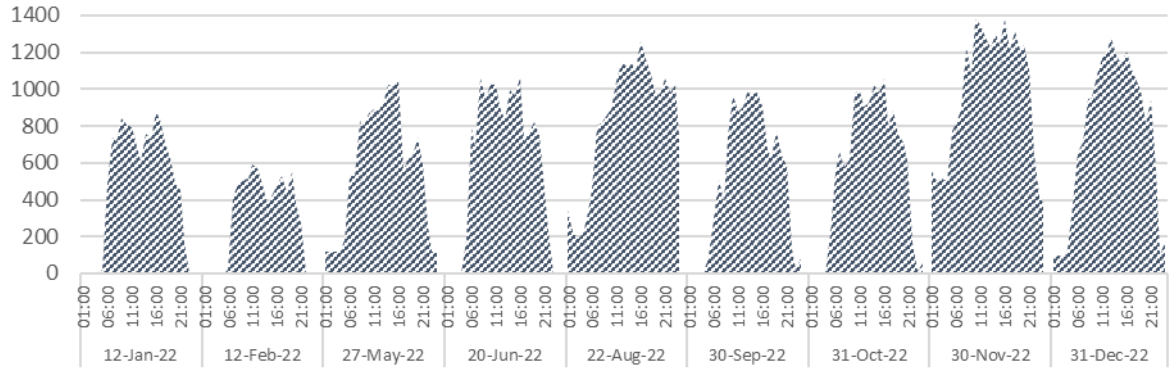
[2] Temporary interruption of electricity services to parts of the grid, when the power system does not have sufficient capacity to meet demand, to maintain the integrity of the power system and to prevent grid failures and extended outages.

Figure 1. Hourly load and load shedding on December 31, 2022 (MW)



Source: WB staff estimates

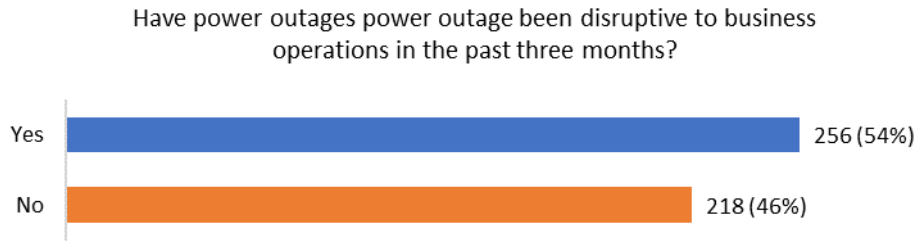
Figure 2. Hourly load shedding on selected days in 2022 (MW)



Source: WB staff estimates

According to the Myanmar Firm Survey conducted by the World Bank in December 2022, about 54 percent of surveyed firms reported that power outages had been disruptive to their business operations in the past three months. Among the firms that responded to the outages, 91 percent invested in diesel generators, 22 percent invested in off-grid power systems such as solar photovoltaic (PV) or micro-hydro, and 11 percent reduced operating hours. Firms that have not taken any measures plan to reduce operating hours or invest in diesel generators to cope with power outages (Figures 3, 4, and 5). Since early 2023, 42 percent of all firms and over half of manufacturing firms report power outages as the most significant constraint to their operations.

Figure 3. More than a half of the firms experiencing disruption from power outages



Source: World Bank Myanmar Firm Monitoring Survey, December 2022.

Figure 4. Investing in diesel generators is the most prevalent solution to address the outages

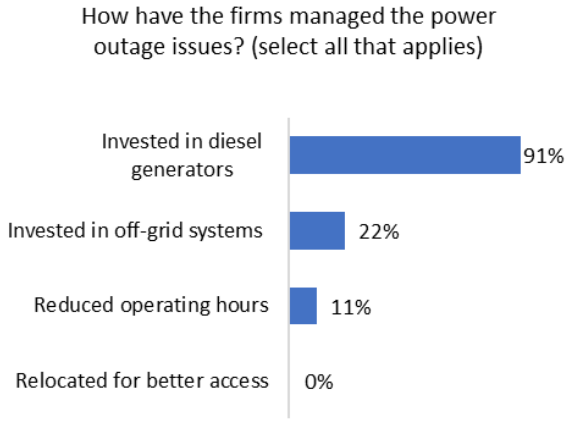
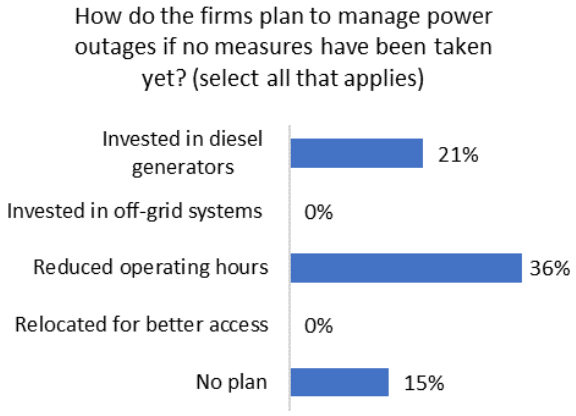


Figure 5. Firms that have not taken any measures tend to reduce operating hours



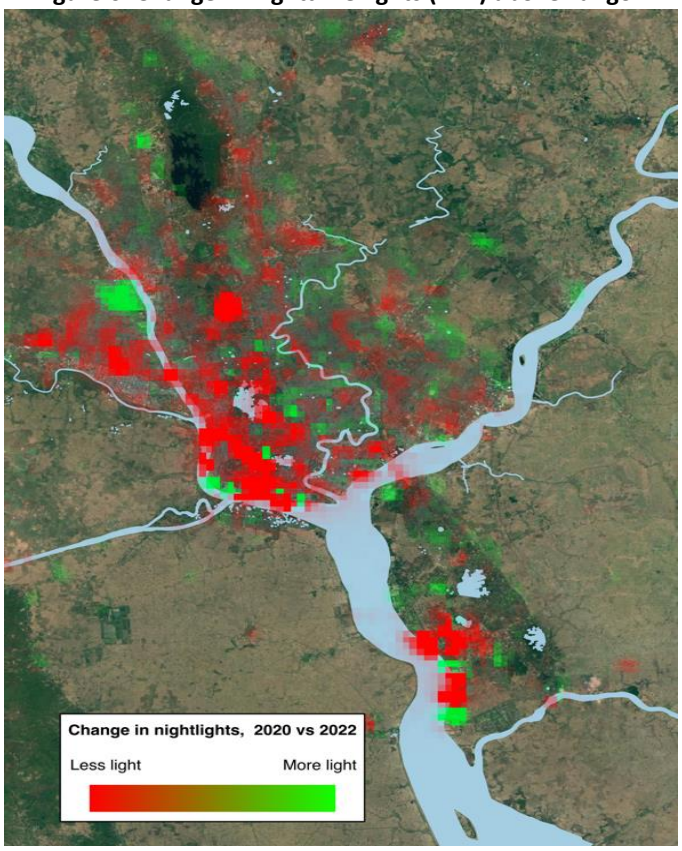
Source: World Bank Myanmar Firm Monitoring Survey, December 2022.

The scale of the power shortage is large enough to affect Myanmar's nighttime lights (NTL). Figure 6 shows, in red, the areas of Yangon where NTL have significantly decreased during that period; and in green, the areas producing more NTL. The downward trend is visible in most parts of the city, including the city centre and industrial areas (Hlaingtharyar, Shwepyitar, Mingalardon, Thilawa).

Poor power supply has had a particularly big impact on industrial zones. The Charts A and B in Figure 7 are time series indices of average NTL radiance above industrial zones in Myanmar. Chart A illustrates a sample of industrial zones that rely on the national grid supply. Chart B illustrates industrial and trade zones in border areas where electricity can come from either side of the border. The major industrial zones saw their NTL radiance significantly dimmed in 2022 after several years of rapid growth. By contrast, NTL of the border zones increased in 2022 due to escalation of business activities at border trade posts.

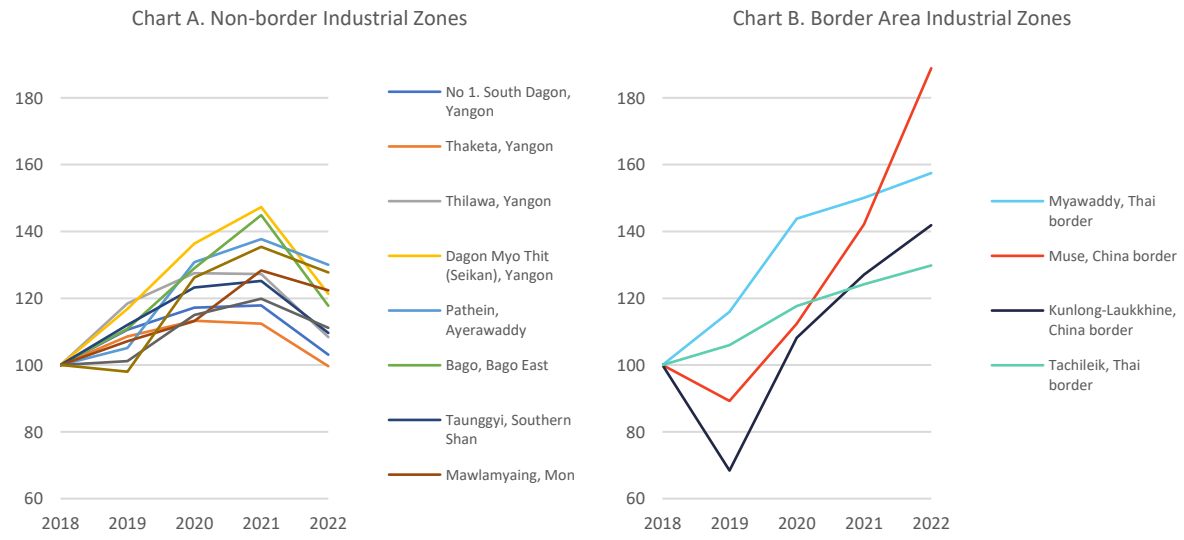
Due to poor power supply, the authorities have tried to inform customers ahead of time by implementing a rolling-outage schedule across the country. Consequently, the Ministry of Electric Power (MOEP) started recording "Planned Loadshedding" in its statistics in April 2022. The utilities Electricity Supply Enterprise (ESE), Yangon Electricity Supply Corporation (YESC), and Mandalay Electricity Supply Corporation (MESC) occasionally publish the power-cut schedule for each area in local newspapers or on social media such as Facebook. The most common power-rationing practice in cities and towns is 8 hours on and 8 hours off, or 4 hours on and 4 hours off. However, interviews with residents in Shan State, Kayin, Mandalay and Yangon reveal that despite the schedules, unplanned loadshedding remains widespread. Rural areas face a harsher reality, with power cuts sometimes lasting several days. None of the respondents interviewed in villages were aware of a power-cut schedule.

Figure 6. Change in nighttime lights (NTL) above Yangon



Source: World Bank staff estimates based on VIIRS Stray Light Corrected data
Note: From the National Oceanographic and Atmospheric Agency, through Google Earth Engine. VIIRS Stray Light Corrected monthly composites, 463.83-meter resolution. A minimum of three cloud-free images is set for each pixel.

Figure 7. Nighttime light (NTL) radiance index in industrial zones, 2018-2022



Source: World Bank staff estimates based on VIIRS Stray Light Corrected data, through Google Earth Engine.
Note: Index indicates the yearly average nighttime light radiance as a percentage of the average for the base year of 2018. The yearly average is calculated from the monthly composites, excluding June-October due to cloud coverage. 2022 does not include December, as that data has not yet been released.

Access to electricity has been slowing down. Before the military takeover, the national electrification program, with a goal of reaching universal access to electricity by 2030, made significant progress. The program had increased access to electricity from 39.1 percent in September 2017 to 57.9 percent in November 2020, or on average 6 percent per year at the household level, by attracting substantial private sector financing in power generation and increased public investments in the development of transmission and distribution systems. However, from the latest available data in December 2021, the household electrification rate was only 61.6 percent, an increase of 3.7 percent over one year. More than four million households remain without access to electricity.

All walks of life across the country feel the effects of the energy shortage. Power outages in Yangon have caused long queues at the compress natural gas (CNG) filling stations, primarily for public transport vehicles, including buses operated by the Yangon Bus Services and taxis, resulting in a shortage of public transport services for commuters. Healthcare workers cannot keep essential medication and test samples refrigerated. Most, if not all, industry, factory, and commercial buildings have used their own diesel generators for operations during the power outages. This negatively impacts the competitiveness of the low-margin garment industry that dominates the country's manufactured goods exports.

II. Key Challenges in the Power Sector

Myanmar's power sector expanded rapidly during the past decade, relying on natural gas and hydropower to meet fast-growing electricity demands. The total installed generating capacity increased from about 2,800 MW in 2010 to 7,100 MW in 2022. As of December 2022, natural gas accounts for 50 percent of the total installed capacity (3,567 MW), followed by hydropower for 45 percent (3,225 MW), ground mounted solar for 3 percent (192 MW), and coal for 2 percent (138 MW). Currently, natural gas-fired power plants supply the baseload, while hydropower is used for daytime peak load. Most gas-based generating capacity is in Yangon metropolitan area, including the country's only two LNG-to-power plants. The remaining are in Mandalay, Bago, Magway, Mon, Rakhine and Ayerawaddy. Hydropower generation is concentrated in Shan, Kayah and Kachin states, with smaller units in the hills of Bago, Magway and Sagaing regions.

A. Widening power supply–demand gap

In 2019, a widening supply–demand gap became evident when the country faced widespread power shortages with load shedding reaching approximately 300 MW during the summer months (March to June). At that time, the supply–demand gap was expected to increase substantially in the short-to-medium term, assuming the continuous growth in demand and reflecting a limited pipeline of projects under construction (Figure 8 and 9). Electricity tariffs remained below cost for a long time, undermining sector financial sustainability and deteriorating the investment climate for the power sector.

Figure 8. Forecasted supply–demand gap (as of 2019)

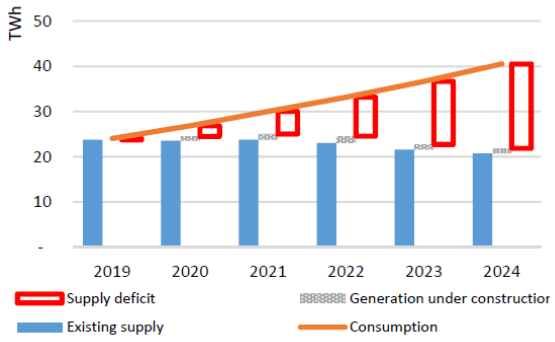
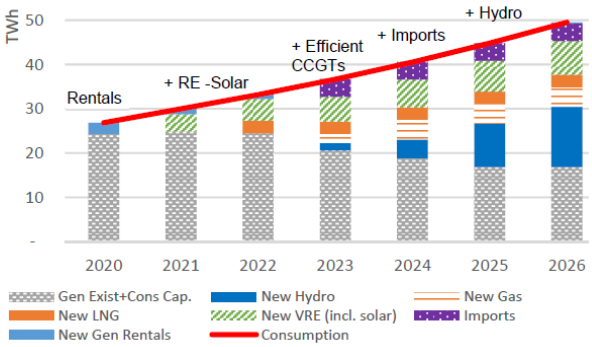


Figure 9. Indicative least-cost generation expansion plan (as of 2019)



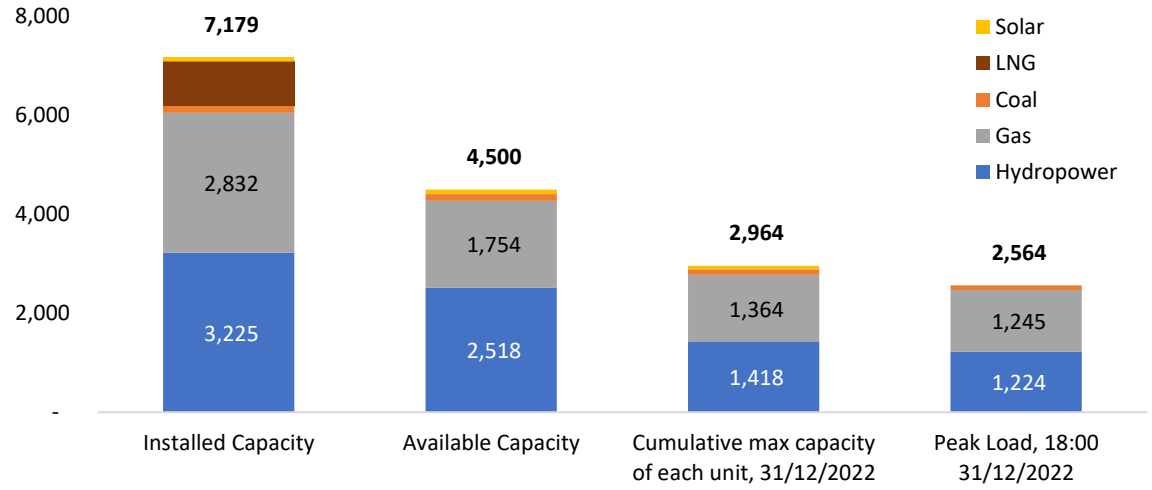
Source: World Bank staff estimates.
Note: The analysis was conducted in 2019 using the World Bank Electricity Planning Model for 2019–2030, which optimizes system-wide costs, including (annualized) capital cost of new plants, operating costs of new and existing plants, and cost of unserved energy and capacity reserve. The Electricity Planning Model considers the physical constraints on transmission between north and south Myanmar, monthly hydro energy limits, reserve margin requirements, annual limits on domestic gas, spinning reserve requirements, minimum variable renewable energy limits, and hourly profiles of demand and solar/wind generation.

The previous government sought to close a growing power supply–demand gap and improve cost recovery of the power sector. The options pursued were procuring emergency rental plants in the short term and developing renewable energy in the medium to long term. Five emergency rental gas power plants totalling 1,040 MW were tendered in June 2019 and came online in less than a year. Several other medium-to-long term projects were initiated, including LNG-to-power, hydropower, solar PV, and imported power from China and Lao PDR. The electricity tariff was significantly increased in July 2019 for residential, commercial, and industrial consumers, after a five-year gap of no tariff adjustments. The electricity tariff reform resulted in tariffs reaching close to operational cost recovery levels by increasing the system's revenues while a lifeline tariff was established to reduce the impact of the increase on the poorest.

More recently, the available capacity, or generating capacity available for dispatch, has significantly declined. Available capacity is defined as the cumulative capacity of power plants that the Load Dispatch Center considers being available. On December 31, 2022, total installed capacity reached 7,179 MW, whereas available capacity was 4,500 MW (Figure 10). The difference was driven by several factors. Two LNG-to-power plants in Yangon had stopped electricity generation since July 2021 and contributed to a 750 MW drop in available capacity. Low precipitation and water levels in reservoirs reduced available hydropower capacity. Two hydropower plants, about 350 MW in total, exported most generation to Yunnan, China. Gas supply shortages, due to either lower domestic gas production or problems with the pipeline network, led to a reduction of the effective capacity of gas-to-power plants, which are already known to be obsolete and inefficient and therefore unable to operate at full capacity.[3]

[3] This issue, particularly present in Yangon, is described in detail in Data Collection Survey on Urgent Upgrade of Electricity Supply in the Republic of Union of Myanmar (JICA, October 2017).

Figure 10. Comparison between installed and available capacity (MW)



Source: WB staff estimates.
Note: Cumulative max capacity is the sum of the maximum power output of each generation unit, which may come at different times of a day. Peak load is the maximum power output of the entire power system at a given hour.

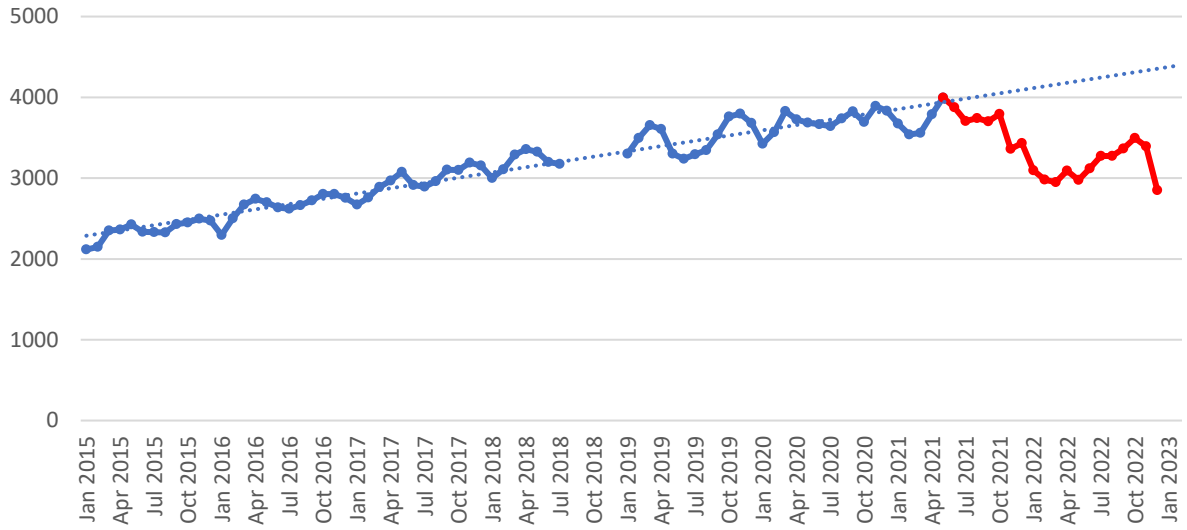
Electricity supply capacity, especially in the Yangon metropolitan area, has been in decline since July 2021 when two LNG-to-power plants in Yangon (Tharketa-400 MW and Thanlyin-350 MW) suspended operations due to rising global LNG prices, payment issues, and low forex liquidity. Electricity generated from LNG power plants is paid in local currency whereas imported LNG from regional markets requires payment in US dollars, effectively leaving currency convertibility risks to the operator. The Myanmar LNG import facility, located at Thilawa industrial port on the Yangon River, includes an LNG floating storage unit. This unit stores imported LNG that is transformed to gas and supplied to natural gas-fired electric power plants in Yangon area. Because of its shallow depth, the Yangon River is only navigable by small-scale LNG vessels. The storage capacity of the LNG floating storage unit anchored at Yangon held 12,600 cubic meters of liquified gas. Myanmar has not imported LNG since mid-2021. The LNG floating storage unit, which had been moored at Thilawa port since November 2020, left the country in March 2023.

To maximize total daily power supply, electricity generation was ramped up from hydropower plants to compensate for lower electricity generation from gas-fired power plants. More water resources were utilized from the hydroelectric reservoir since the beginning of the rainy season. The practice resulted in the depletion of water resource at a faster pace than the normal mode of operation. The efficiency of hydropower operation sharply declines as water levels drop in the reservoir. Therefore, the acute electricity shortage was worsened in the dry season from January to May 2023.

The amount of power generation capacity effectively used by load dispatchers is significantly lower than available capacity. At the most recent available data point on December 31, 2022, the sum of the maximum used capacity of every power plant over a 24-hour period was 2,964 MW. On that day, a peak load of 2,564 MW was reached between 6:00 and 7:00 pm. Throughout the month of December, daily peak load oscillated between 2,564 MW and 2,851 MW. In the first quarter of 2023, that figure remained in the range of 2,400-2,800 MW.

Monthly maximum load has significantly declined since early 2021. Myanmar's maximum effective generating capacity dropped by 1,047 MW within 10 months of its May 2021 peak (Figure 11). Available capacity in the dry season has dropped from 3,500-4,000 MW to 2,400-3,000 MW. While electricity demand could be reduced due to the pandemic and economic recession, the decline would be explained more likely due to the limited available capacity in the power system.

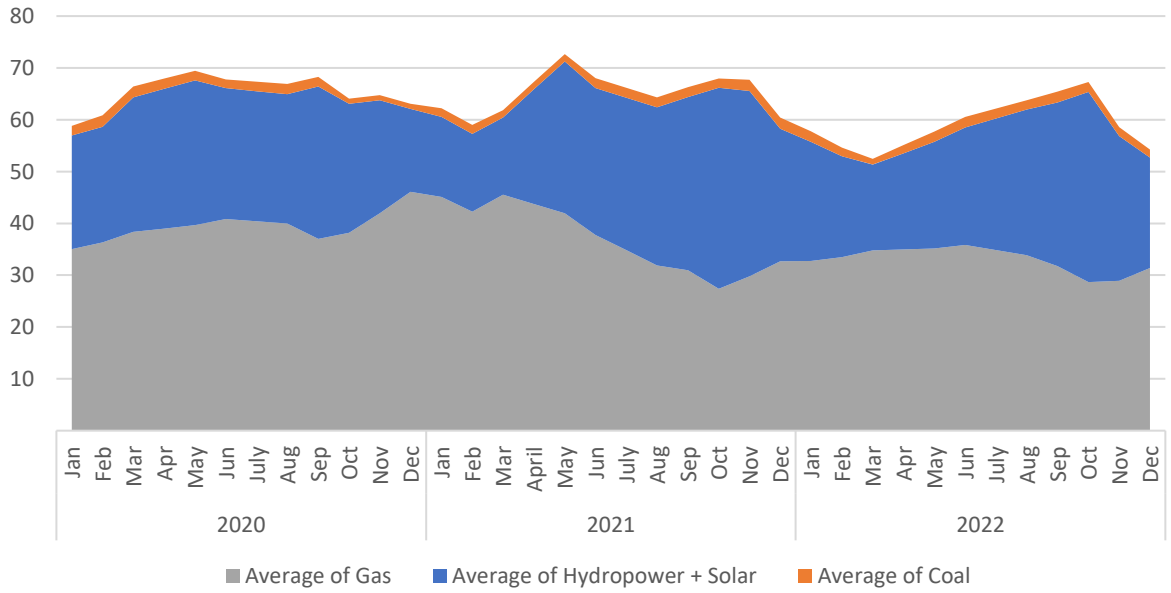
Figure 11. Monthly maximum load (MW)



Source: WB staff estimates

Fuel mix in power generation, therefore, has changed over time. The drop in gas generation is visible in Figure 12, as are the efforts by MOEP to ramp up hydropower production to compensate for it. That has achieved mixed results. The amount of hydropower production increased in 2022 compared to 2020 but failed to recover to its 2018 levels. In the fourth quarter of 2022, hydropower output remained one-third of what it was at the same period in 2018. Overexploiting hydropower in 2021 resulted in the overall water levels of dams declining in September, 3-4 months earlier than usual. Consequently, there was a sharp drop-off in the amount of water available for electricity production and irrigation in January 2022. More intensive use of dams has caused more wear and tear. Four hydropower units had to be temporarily disabled for maintenance operations in mid-2022, including Myanmar's second biggest dam, Shweli-1. This further reduced available capacity.

Figure 12. Average daily electricity generation by source, 2020-2022 (GWh)



Source: WB staff estimates

While supply capacity is constrained, electricity demand could grow if there is an economic recovery. Currently, there is no robust and credible assessment of current and future electricity demand in Myanmar. According to the last estimates from the Power Sector Master Plan, which was prepared in 2020, consumption was projected to grow at an average annual rate of 11.1 percent until 2030, based on assumptions of an average GDP growth rate of 7.5 percent in the medium term. However, these estimates do not reflect the recent economic slowdown and impact of the political crisis since 2021.

Developing additional generating capacity is essential to address the widening demand–supply gap in the power sector. Myanmar, however, faces difficulties on this front**.** With declining available capacity and potential moderate demand growth, it is becoming a fundamental challenge to reduce the power demand–supply gap. Myanmar had a difficult time trying to mobilize investment in additional generating capacity in the past, and now it is even more difficult to meet the large investment needs.

More than 2 gigawatts (GW) of natural gas-based power plants involving foreign direct investment are on hold. Mee Lin Gyaing, the 1,390-MW LNG-to-power project with China, was discussed and approved by the authorities prior to 2021 but stalled without much progress since then. Ahlone, the 388-MW LNG-to-power project with an Italian-Thai development company, signed the power purchase agreement in January 2021, but there has been no movement since then. The 600-MW gas power plant of the Thai company, PTT Exploration and Production in Kyaiklat, was officially delayed in January 2023.

The MOEP-led hydropower plants that started construction before 2021 continue with slow progress. Insufficient resources and armed conflicts around the sites caused delays in construction. The completion of the 280-MW Upper Yeywa was postponed from December 2023 to March 2025. The 111-MW Thahtay delayed commissioning to 2026. The 52-MW Upper Keng Tawng was scheduled to be commissioned in 2019 but now delayed to 2025. A series of satellite images between January 2021 and March 2023 show slow progress of the construction sites of these hydropower plants. In addition, a tender was launched for feasibility studies of 10 new hydropower plants in 2022, but no further information is available.

The MOEP has counted on solar PV to quickly address the demand–supply gap, but associated tenders have not demonstrated much success. The first solar tender for 1,060 MW in 2020 had well-received responses and resulted in 28 out of 29 projects being awarded at competitive pricing. However, only one project seems to have been commissioned after other winning bidders stepped away after the military takeover. The second tender for 12 solar PV projects was launched in May 2021. Of these 12 projects, four have been commissioned and two are under construction as of May 2023; the other six are reportedly not moving forward. The third solar tender for 18 sites for 610 MW in total was announced in June 2022. The deadline for the tender was extended twice because of a lack of bidders. Two companies were identified to have submitted bids, but no further update is available. In June 2022, MOEP awarded three floating solar PV projects to a newly formed company with no tender, and no progress has been identified. In March 2023, a consortium of two state-owned Chinese companies and a Burmese company announced a plan to build three wind farms in Rakhine state with a total 360-MW capacity.

The declining domestic supply of natural gas is expected to have a substantial decrease in the coming years further constraining gas-based power generating capacity. Although Myanmar is a leading natural gas-exporting country by pipeline in Southeast Asia, the gas supply for domestic industry, including the power sector, is always insufficient. This shortfall is because about 80 percent of production has been sold under long-term contracts to neighbouring Thailand and China. The gas pipeline connected from offshore gas fields to Yangon area is old and obsolete. In addition, the capacity

of the gas pipeline connecting Kanbauk to Yangon, transporting gas from Yadana and Zawtika fields, has been constrained due to the impact of armed conflicts. The quality of repair and regular maintenance is poor due to insufficient budget allocation. As a result, natural gas has been rationed to various domestic industries such as power plants, cement factories, fertilizer factories, and steel mills. The natural gas supply to domestic industries is projected to decline by about 80 percent between 2022 and 2030, assuming that the export shares to China and Thailand remain constant and that no additional gas field will be developed, or no LNG terminals will be connected to a domestic gas pipeline network. Such reduction in domestic gas supply is expected to lead to the significant reduction in electricity generation from gas-to-power plants.

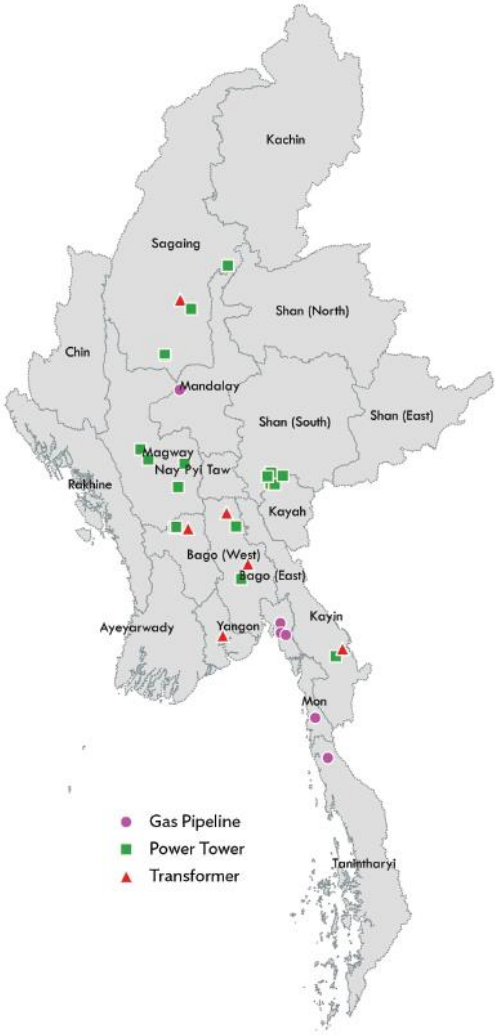
B. Constrained grid network capacity

The electricity transmission and distribution network has been attacked and damaged amid armed conflicts. Transmission towers, high voltage lines, and substations have all been targeted (Figure 13). Authorities claim that the power grid has been attacked 229 times between February 2021 and April 2023. The power grid in Myanmar is fragile without much back-up capacity. Damages in one area have led to electricity supply constraints and blackouts in other areas.

Electricity utility offices and personnel across the nation have been targeted also. Since July 2021, electricity utility officers and bill collectors were targeted to deter forced collection of electricity bills and to prevent cutting power lines to those households who are boycotting bill payment. In addition to the difficulty collecting electricity bills, workers in some cases could not access some sites safely to repair the damaged transmission and distribution network.

Damaged power infrastructure has had impact on reliability of the power supply. Since early 2021, about 77 percent of existing power plants have been within 10 kilometers of a conflict-related fatalities. Eleven power plants, including several hydropower plants and gas-to-power plants, stopped electricity generation temporarily due to the conflicts. For these cases, transmission lines or substations connecting those power plants were damaged, gas pipelines to those plants were destroyed, or power plants themselves were temporarily occupied by the resistance force.

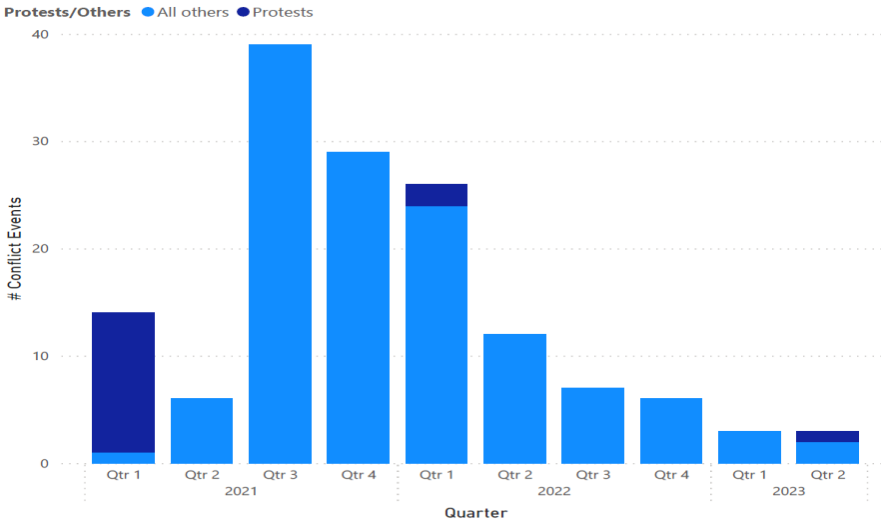
Figure 13. Attacks on energy infrastructure (August 2021 – February 2023)



Source: Myanmar Institute for Peace and Security.

The reported number of conflict-related incidents on electricity infrastructure has been declining following the peak in late 2021 and early 2022, but grid network capacity remains vulnerable. While the number of conflict-related incidents went down after the 2021-22 peak (Figure 14), attacks on the grid network continues to be reported and affect the grid capacity. For instance, on April 4, 2023, there was a nationwide power outage for six hours due to attacks on a key substation in Bago East region.

Figure 14. Conflict events affecting electricity infrastructure/personnel

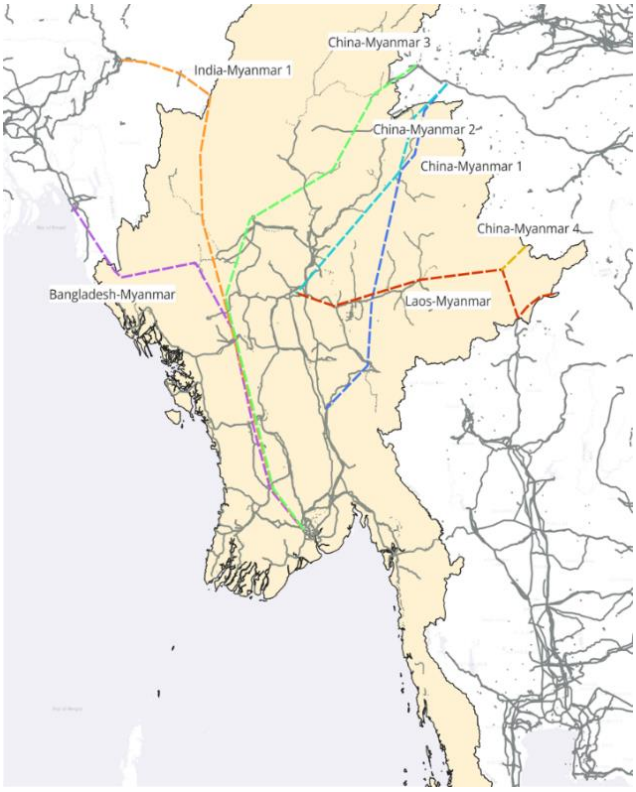


Source: World Bank staff estimates, based on Armed Conflict Location & Event Data Project (ACLED) Data

Transmission network expansion has not made much progress since February 2021. A five hundred kilovolt (500 kV) transmission line connecting Yangon and Mandalay was planned before the military takeover. This transmission line was meant to address the bottleneck in electricity transmission between upper and lower Myanmar and enhance grid capacity. However, progress of this transmission network construction has been slow since 2021. Other planned transmission network expansion projects such as 230 kV to southern Tanintharyi Region have been postponed.

Developing grid interconnection importation with other countries has not progressed. Prior to 2021, to address the anticipated power supply–demand gap, power grid interconnection was explored among the neighboring China, Lao PDR, Bangladesh, and India (Figure 15). Discussions with China and Lao PDR progressed, but the project has not advanced much since 2021. Interconnection with India and Bangladesh has been under discussion too, but proceeding would be challenging as the lines would have to go through conflict-active states such as Magway, Rakhine, and Chin.

Figure 15. Proposed power grid interconnection with neighboring countries

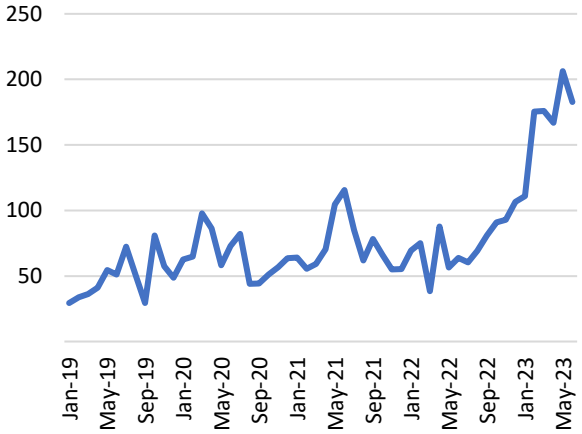


Source: World Bank staff estimates

Electricity imports from China to border trade posts have grown since early 2023. Developing more power import–export capacity with China remains feasible, but progress has been slow with interconnections and transmission lines**.** This transmission line for importing 1,000 MW of power between Myanmar's Northern Shan state and China's Yunnan province has been discussed for years and was included in the Generation Plan 2018-19 as a potential project to be completed by

2025. Discussions between the two utilities on technical design and commercial transaction have not made much progress. Consequently, construction of high voltage interconnected transmission line has not begun on either side yet. Despite limited progress in building new interconnection lines, the average monthly electricity imports from China through medium voltage lines during the first six months of 2023 more than doubled the average monthly electricity imports during 2022, from 74 GWh to 170 GWh per month (Figure 16). Imported electricity from China is distributed solely to communities living in China-Myanmar border area and it has reflected in NTL radiance above border area in the Charts B of Figure 7.

Figure 16. Monthly electricity imports from China (GWh)



Source: China Customs Department

Power import plan from Lao PDR appears to have moved ahead, but its implementation may take time. A Memorandum of Understanding was signed in 2018 between the two energy ministries of Myanmar and Lao PDR to build an interconnection line to import 300 MW of power through eastern and southern Shan to Meiktila. It also included plans for hydropower development. In April 2023, the Memorandum was extended for five years, and a Notice to Proceed was signed to conduct a feasibility study. The import capacity was upgraded to 600 MW. It was also announced that the interconnection line would reach Keng Tung in 2024 and Meiktila in 2026. Construction could be challenging as the proposed interconnection route will likely pass through conflict-affected southern Wa state.

Developing cross-border power trade and market is complicated despite being an effective solution to address the growing power supply–demand gap. In addition to mobilizing capital for significant investment in physical transmission infrastructure, cross-border projects require political consensus among countries. There must be mutual agreements on technical designs and regulations to ensure system stability and safety and on commercial framework under which utility companies in different countries enter into negotiations and power trade agreements. The progress on regional interconnection among ASEAN countries over the past decades has been impeded by disagreements on these necessary cooperative factors. While power trade and imports could help ease the electricity supply shortages, it remains challenging under the current political circumstance in Myanmar.

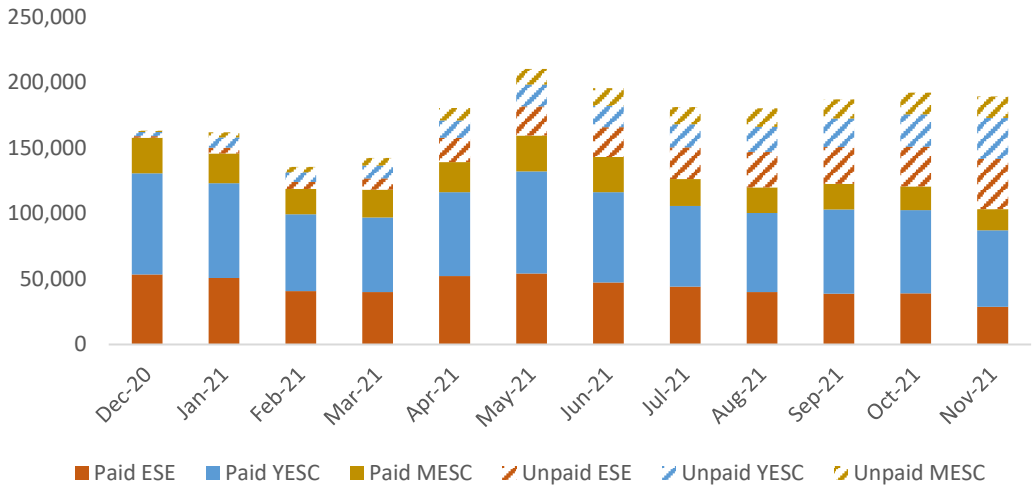
C. Deteriorating sector financial performance

Myanmar's power sector continues to record losses due to a combination of several factors, including currency depreciation, increasing grid maintenance cost, and revenue decline. Despite ambitious tariff adjustment in July 2019, the power sector was not at cost recovery. It was estimated that the financial deficit in the sector would be reduced from 960 billion MMK (US$640 million equivalent) in FY2018 to 657 billion MMK (US$434 million equivalent) in FY2019. Since then, the Myanmar kyat has depreciated by over 30 percent against the US dollar, pushing hard currency-linked power purchase prices upward from independent power producers while the retail tariff remains unchanged. The pandemic-induced subsidy of the first 150 units of free electricity usage, valued at 11,550 MMK per month (US$5.5 equivalent), was provided for every residential consumer from April 2020 to March 2021. This year-long subsidy further reduced revenue by an estimated 20 percent. Increasing attacks and damages to the grid network added on grid maintenance costs.

The overall cost structure in power generation might have been slightly improved since gas-based generation declined by 13 percent and hydropower generation increased, which is less costly. Several short-term rentals, independent power producers left the country after February 2021, and gas supply shortage led to the generation reduction. While it is difficult to quantify these impacts, it is not likely that the slight improvement in generation costs would have made up the sectoral deficit and the additional impact of currency depreciation, pandemic subsidy, and grid maintenance cost.

Cash flow within the power sector was also impacted by unpaid electricity bills. The military takeover in 2021 triggered a country-wide boycott of electricity bill payments, significantly plummeting bill repayment across the country. Before 2021, Myanmar had exceptionally high bill repayment rates of over 97 percent. The unpaid portion of the revenue increased over time, reaching up to 45 percent in November 2021 (Figure 17). Authorities have prioritized increasing bill payment collection and pressuring customers by disconnecting the electric lines of unpaid customers. However, collection rates seem not to have recovered to pre-2021 level.

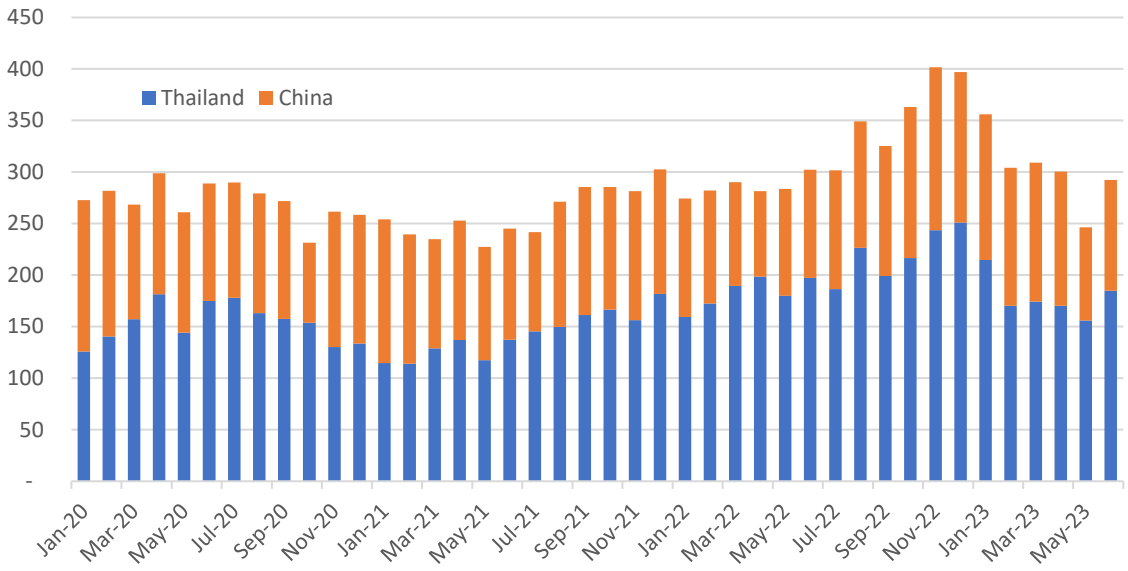
Figure 17. Monthly electricity revenue, paid and unpaid (MMK million)



Source: WB staff estimates

Natural gas export value, which is the major source of income for the energy sector, remains strong. Four offshore fields account for almost all the country's natural gas production, a large share of which is committed to export markets in Thailand and China. The Yadana, Yetagun, and Zawtika fields exported a total of 684 million standard cubic feet per day (MMscf/d) or about 250 billion cubic feet (Bcf) amounting US$2,421 million to Thailand in 2022. The Shwe field exported approximately 390 MMscf/d or 140 Bcf amounting US$1,431 million to China in 2022. In the second half of 2022, export value was higher than earlier in the year, reflecting global natural gas price increase. In the first six months of 2023 however, export value from Thailand declined as export volume dropped notably. Export value from China was relatively stable during the same period, but export volume data was not disclosed.

Figure 18. Monthly gas export value to China and Thailand (US$ million)



Source: World Bank staff estimates using data from China and Thailand Customs Offices.

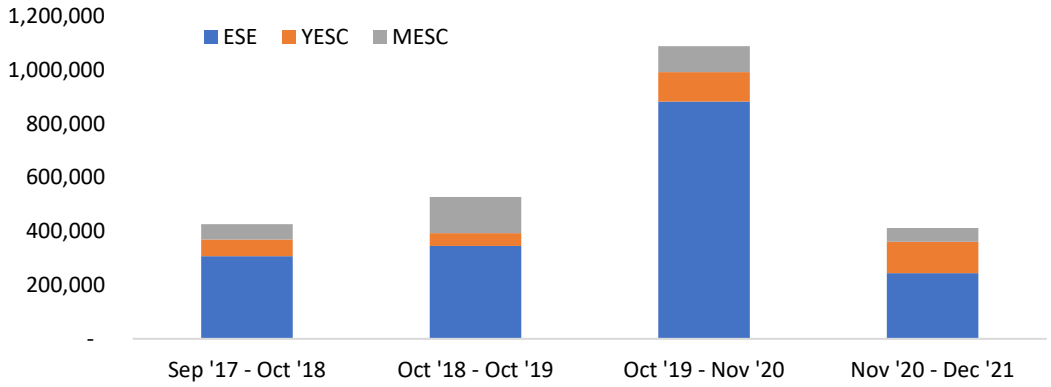
For the entire energy sector, financial deficit may remain manageable. Myanmar's energy sector is managed by the Ministry of Electric Power (MOEP) and the Ministry of Energy (MOE), which together account for over one-third of public sector revenue. Before May 2022, the two ministries operated under one single Ministry of Electricity and Energy (MOEE). While the power sector under MOEP is running below cost recovery and mounting deficit, the oil and gas sector under MOE remains a large source of revenue. On Myanmar's fiscal year basis (from April to March), the value of natural gas export to China and Thailand increased from US$3,240 million (MMK 6,804 billion equivalent) in FY2022 to US$3,975 million (MMK 8,34 billion equivalent) in FY2023. Some estimates suggest that as much as 50 percent of the export value of natural gas could be contributing to the revenue. Based on this, the incremental revenue to MOE in FY2023 is estimated to be about US$367 million (MMK 771 billion equivalent), which can be a substantial contribution to the financial position of the energy sector as well as the overall fiscal balance.

D. Slow progress in energy access

Prior to 2021, the implementation of the National Electrification Plan, with support of the World Bank and other development partners, led to substantial improvement of the electrification rate, from 39.1 percent in September 2017 to 57.9 percent in November 2020 at household level. It was made possible by attracting substantial private sector financing in power generation and increased public investments in the development of transmission and distribution system.

However, the prospects of achieving universal access to electricity by 2030 have dimmed in Myanmar. The growth in access rate has slowed down since 2021. Between November 2020 and December 2021, the electrification rate at the household level increased from 57.9 percent to 61.6 percent, only 3.7 percent increase over a year. The incremental number of electrified households was 412,829, less than a half of the previous year's achievement (Figure 19).

Figure 19. Number of households that have been newly electrified



Source: WB staff estimates

Petroleum fuel prices have skyrocketed upwards since 2021. The shortage of fuel during certain months in 2022, compounded by further depreciation of Myanmar kyat, pushed up premium diesel prices to a record 3,300 MMK per liter in Yangon in August 2022 (Figure 20). Other parts of Myanmar, where additional transportation is required, reached around 3,500-3,900 MMK per liter for premium diesel. Gasoline prices also nearly tripled in 2022 compared to 2021. The prices stabilized in October 2022 due to the higher import volume of diesel and gasoline into the country but remain two to three times higher than before.

Figure 20. Fuel prices in Yangon

Source: DENKO Daily Fuel rates.

Extremely high fuel prices put pressure on mini-grid operators and businesses, deteriorating access to electricity. Diesel-based mini-grids represented a total of 101 MW of installed capacity in 2020. The 84 percent of the business firms, which were surveyed under the Myanmar Firm Monitoring Survey, reported the use of captive diesel generators as a means of responding to unstable power supply and blackouts. With surging diesel prices and supply shortage, many mini-grid operators found it challenging to supply fuel and recover their cost of services, leading to frequent power cuts and a significant increase of electricity tariff. Households and businesses in off-grid communities therefore have been also experiencing power shortages and disruptions in economic activities. Businesses have been largely relying on captive diesel generators to address unreliable electricity supply from grid or off-grid, but even such an emergency option is not working well as fuel is expensive and hard to buy.

Companies affected by the power cut had to reduce their operating hours or even suspend their operations.

Distributed renewable energy is gaining more ground in meeting electricity demand in the country, but supply chains and access to finance are impediments to further scale up. As prevalent diesel-based backup plans are becoming expensive and losing financial viability, distributed renewable energy applications, ranging from rooftop solar PV and battery storage to standalone solar home systems, are getting attention as cost-effective alternatives. However, suppliers and developers of distributed renewable energy systems experience challenges in access to financing. Seed capital, including bilateral and multilateral funding, has been suspended; and local financing has been constrained as the foreign exchange transaction of domestic banking system has been substantially regulated since the military takeover. This lack of access to financing led to equipment import and supply chain disruptions, which again amplified difficulties in disseminating distributed renewable energy applications. Only 10 percent of the surveyed firms have invested in off-grid solutions, and 8 percent of the surveyed firms that have not taken any measures for power shortages responded that they have a plan to invest in off-grid systems.

III. Scenario Analyses

Given the significant shortage of installed and available generating capacity in the power system, the status of power generation projects will have a critical impact on meeting electricity demand going forward. Three scenarios have been developed to estimate the electricity gap by 2030. The scenarios assess potential available generating capacity based on assumptions on the implementation of planned and announced upcoming projects, declining domestic natural gas production, rising electricity demand, and the potential impact of ongoing conflict.

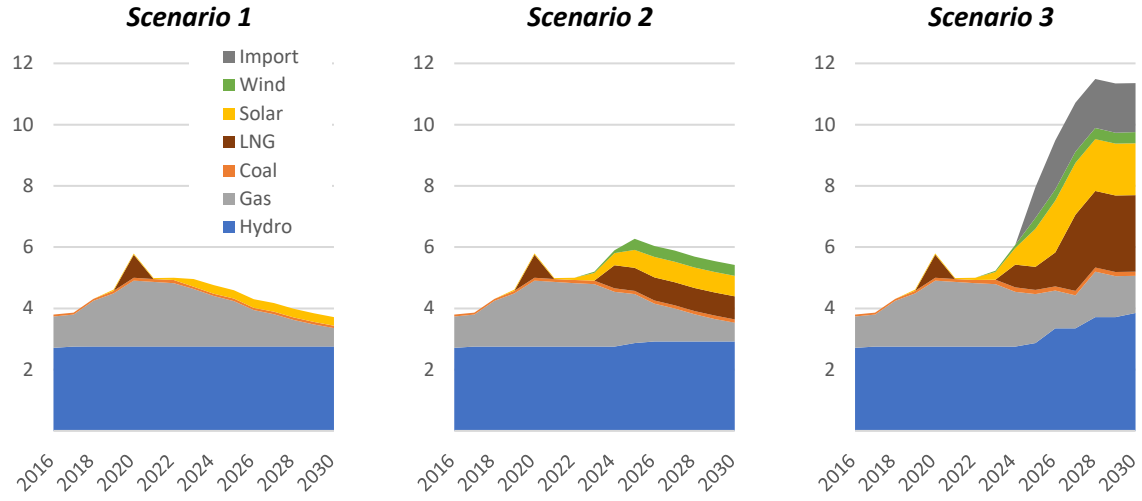
The scenario-based analyses are built on assessment of the likelihood of delivery of each project and its delivery dates. It should not be seen as a forecast of project delivery but an assumption to illustrate the varying magnitude of the challenges across different scenarios (Figures 21 and 22). The three scenarios used in the analyses are the following:

***Scenario 1*:** This scenario assumes that no power project is delivered and therefore no additional generating capacity is added until 2030. Furthermore, following domestic gas production reduction, available generating capacity of gas-to-power plants also declines.

***Scenario 2*:** Reflecting the current situation in Myanmar, this scenario assumes some power projects, which may be more advanced and located in less conflict-sensitive areas at this stage, to be delivered by 2030 providing incremental generating capacity over time.

***Scenario 3*:** As an illustration, this extreme scenario demonstrates on-time delivery of all announced and planned projects although it is not likely to happen under current circumstances.

Figure 21. Projected available generating capacity (GW) by scenario



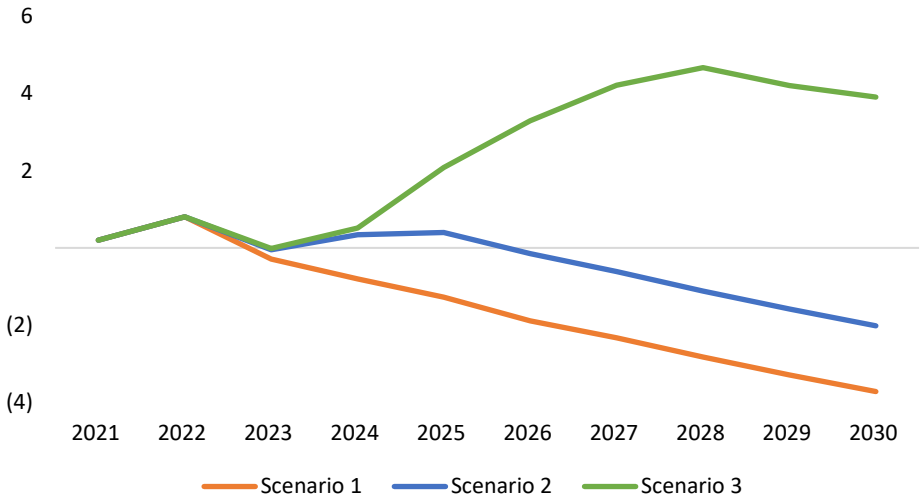
Source: World Bank staff estimates.

Under Scenario 1, available generating capacity would be projected to drop by 37 percent in 2030. Myanmar's available capacity will have slipped back to its 2014 level. While existing hydropower plants will continuously provide about 2.8 GW of capacity, gas-to-power capacity will significantly decline from 2 GW now to 600 MW in 2030 due to declining domestic gas availability. The Yadana gas field will be depleted by 2027, and the production of the Zawtika gas field will have declined by 60 percent in 2030. All LNG terminals would remain disconnected from the domestic pipeline network, and no additional LNG-to-power capacity would be introduced.

Scenario 2 demonstrates a temporary increase in generating capacity, which peaks in 2025 before declining again to 2030. The available generating capacity would continue to increase with the completion and delivery of several projects, including primarily 600-MW solar PV from the 2021 tendered, 750-MW VPower Energy's LNG-to-power plants reinstated, and 360-MW wind power projects in Rakhine delivered. However, as domestic gas supplies dry up, the available capacity from gas-to-power would decline fast. In 2030, the total available generating capacity would reach about 5.4 GW.

Scenario 3 has the least likely assumptions. Myanmar would recover to its 2020 power generating capacity in 2024. The generation mix then grows and becomes more diversified, evolving from a gas- and hydro-dominated mix to a hydro-, LNG- and renewables-dominated mix. A key assumption of this scenario is that after what seemed like a failed attempt to shift to LNG, Myanmar would resume that transition. It also would require hydropower projects to be built in a timely fashion, which has rarely been the case.

Figure 22. Projected demand-supply gap by scenario (GW)



Source: World Bank staff estimates.

The projected power supply capacity would remain close to the demand and soon fall short of the projected demand under Scenarios 1 and 2, assuming the demand growth at a historical trend. While the available capacity under the Scenarios 2 appears to be able to meet the demand in the next few years, it would be further constrained by regional imbalance, transmission and distribution line bottlenecks, natural gas supply shortage, and other factors. Reliable power supply would continue to be challenging under these scenarios.

While Scenario 3 seems optimistic, there are prevailing challenges that make this scenario difficult to materialize. It would require an influx of private sector investment in all generation sources, which is unlikely in the current political and macroeconomic conditions. The weak financial position of MOEP makes it difficult to commit to high, long-term spending on power purchases. Of the 28 power plants to be built as part of this scenario, 20 are within 10 kilometers of post-2021 conflict-related areas, among which half are considered within highly conflict-sensitive areas. All these factors contribute to high uncertainties on prospects for this scenario.

LNG-to-power generation needs to play a significant role in meeting the growing electricity demand under Scenario 3 but faces difficulties. Resuming LNG-to-power projects requires renegotiation of the Power Purchase Agreement (PPA) with VPower Energy (existing LNG-to-power operator Thaketa and Thilawa) so the prevailing market spot price of LNG would be reflected in the agreement with MOEP. Unless MOEP is willing and able to pay the market price, it may be challenging for the private sector operator to resume operations. Building Mee Laung Gyaing and Ahlone LNG plants is an essential part of Scenario 3. However, the cost of both plants has likely increased since 2020 and will weigh on MOEP finances. At the time of PPA negotiations in 2020, both projects made proposals under eight cent per kilowatt hour (US¢ 8/kWh), based on Brent price of US$35-40 per barrel. Based on the tariff formulas at current Brent prices, the tariffs would be more than US¢ 11/kWh.[4] In reality, the new PPA price would further increase in consideration of VPower's experience, the higher country risk, insurance and financing costs, and the currency depreciation since 2021.

Without significant improvement in the current business environment, Myanmar's power sector might evolve between Scenario 1 and Scenario 2. Some, but not all, of the planned solar and wind

[4] Calculations taken from the financial models of Mee Laung Gyaing and Ahlone LNG projects submitted by the developers to MOEP in early 2020. The assumptions were a 1% political risk insurance premium and a 30-year and 25-year concession time for Mee Laung Gyaing and Ahlone, respectively.

projects could presumably come online. One of the two VPower LNG plants might be reactivated while the other is decommissioned, and the size of the Mee Laung Gyaing and Ahlone LNG projects could be downscaled. The Myanmar-China high voltage grid connection could also be scaled down, or complemented by other connections to Laos PDR, India, or Thailand. Finally, the outcome would depend on changes made to the export share of dams, from the existing ones (Shweli-1, Dapein-1, Chipwi Nge) to planned ones like Hatgyi. Another possibility is that if MOEP has a positive experience with the existing stock of solar projects, it may issue new tenders for more solar in less conflict-affected areas. Ayerawaddy region could be a prime area for more solar as it combines low levels of conflict and greater energy scarcity than most other regions.[5]

IV. Outlook and Risks

Myanmar's power sector will likely continue to experience challenges going forward. In addition to the growing supply–demand gap, the seasonality of hydropower and the vulnerability of the grid network pose immediate concerns to reliable power supply.

To sustain the current level of power supply would require adding 300-500 MW every year until 2030. The electricity supply–demand gap will be exacerbated with difficulties in mobilizing capital investment in power generation and upstream gas exploration. Keeping transmission and distribution networks up will not be straightforward due to the constraints on financial and human resources. The power sector is likely to continue seeing cumulative financial losses from retail tariffs below-cost recovery and low electricity bill collection. With these constraints, the significant progress made on access to electricity in the past will be staggered or likely fall back. Due to political and economic instability and international sanctions in Myanmar, many foreign investors have left the energy sector. Macroeconomic slowdown and depreciation of the local currency has also put strong pressure on financial performance of the sector.

Electricity generation from hydropower, which accounts for more than a half of the available capacity and 40 percent of electricity generation, has a large variation between dry and rainy seasons. Unless gas-fired power plants are fulfilling the base load, Myanmar will likely continue to experience severe power cuts during the dry season and slightly less acute cuts in the remaining months of the year. The main difference is that dry-season cuts would affect rural and urban areas alike and have a crippling effect on economic activity. On average, residential townships in Yangon experienced 4 hours of blackout per day in February 2023, rising to 8 hours through much of March 2023. Diversifying electricity-generation sources is important to mitigate the impact of this seasonality. With limited capital flow to new generation projects, the seasonal variation would continue to constrain power supply during dry seasons.

In the medium to long term, domestic gas depletion and difficulties in mobilizing investment in additional generation sources will likely worsen the power sector situation. Myanmar's domestic gas production has started to decline after a 30-year boom. The output of Yadana started to drop in 2022 while that of Shwe is forecast to fall in 2026. This situation is going to affect Myanmar's exports to Thailand and China, the hard currency income that it represents for the Myanmar Oil and Gas Enterprise (MOGE), and the amount of gas available for domestic consumption. The 2025-2030 period was expected to see a quick decline in gas production from Yadana, Zawtika and Shwe. By 2030, gas production is forecast to be less than one-fifth of its 2022 levels.

[5] Ayerawaddy imports almost all its power from other regions. As a result, it suffers from longer power cuts and major voltage drops that have hindered electrification and industrialization. This is a part of the justification for the Mee Laung Gyaing LNG project.

Additional generating capacity had been planned in the past, but little progress has been observed since 2021. Three hydropower dams under construction have been significantly delayed. In addition to the VPower Energy's LNG-to-power plants that expired under its contract, planned LNG-based generating capacity has stalled due to a spike in global LNG prices and deteriorating investment climate. Most Solar PV projects that were awarded in 2020 have been cancelled. The country needs to increase installed generating capacity to avoid blackouts and loadshedding and narrow the supply–demand gap. Even if some of the additional generation projects currently planned move forward, it would take years to add new generating capacity to the power system.

Many of the challenges in the power sector are structural, fundamental, and linked with political instability, conflict, and macroeconomic conditions. They cannot be easily fixed with short-term measures and require longer-term approaches and steady progress that are based on proper planning over the long-term.

Gaps in power sector infrastructure are massive and cannot be addressed without improvements in the investment climate, which has deteriorated and is exacerbated by the ongoing political and economic crisis.

Political instability and the economic crisis have reduced investor confidence. The MOEP financial losses raise questions whether PPAs will continue to be paid. The depreciation of the currency combined with strict capital controls in an inflationary context means that profits in local currency must be kept in country, where they lose value.

Rebuilding Myanmar's power system will require establishing trust to develop the power sector. Developing solar PV can add incremental generating capacity in a relatively fast manner. In the longer term, Myanmar can revive the development of hydropower and LNG-to-power, which were planned in the past or were under construction but did not materialize. Political and macroeconomic stability is important to improve investment climate for these options on the ground.

Reliable technical and financial data about the power sector is needed. The MOEP has not published basic data on power generation since early January 2022. As highlighted in this report, the financial situation of the sector is concerning though data is not available.

Power imports, which remain challenging under the current country situation, may help reduce the electricity supply gap in the medium to long term.

Developing cross-border power trade is complicated although it is a solution used by many countries to address their growing power supply–demand gaps. The interconnection between China and Myanmar was discussed as part of a trilateral discussion on electric power trade among China, Myanmar, and Bangladesh, and an agreement was reached at a trilateral ministerial meeting in 2018. The plan was initially developed for 1,000 MW of interconnection capacity, or 30 percent of the total, between China and Myanmar. The plan would expand in phases to eventually add Bangladesh. The first interconnection line between China and Myanmar was explored prior to 2021. The interconnection between Myanmar and Lao PDR could be another option in the long term.

In addition to mobilizing capital for significant investment in physical transmission infrastructure, this plan requires political consensus among countries, technical designs and regulations to ensure system stability and safety, and a commercial framework under which utility companies in different countries enter into negotiations and power trade agreements that are mutually beneficial. Regional interconnection among ASEAN countries has made little progress over the past decades. While

increasing imports could help to ease the electricity supply shortages in Myanmar, it remains challenging under the current circumstances.

Improving power sector financial viability and recovering customer confidence are critical for private sector capital mobilization to enhance the quality of electricity services.

Improving the financial sustainability of the power sector is important to enhance the quality of electricity services, build investors' confidence, and mobilize capital investments. It is also crucial in reducing subsidies to the sector in an economically and socially adequate manner and improving the fiscal balance for other competing development priorities. Following its tariff increase in July 2019, Myanmar was working on developing tariff adjustment methodologies and a roadmap towards cost recovery. The effort would have gradually improved overall sector financial viability while low-income and vulnerable households would be offered proper targeted subsidy schemes to protect affordability of their electricity services.

Recovering customer confidence is critical. The electricity bill collection rate dropped significantly after the military takeover. The low collection rate further exacerbated the cost recovery of the sector. Political and economic stability is important to regain the confidence from customers. Providing reliable electricity with cost reflective tariffs to pre-specified distribution networks such as industrial zones, commercial or urban residential areas may be an option to rebuild customer confidence.

Distributed renewable energy solutions can help ease electricity shortages for the population but supply chain issues, access to finance constraints and limited awareness by customers are impediments to scale up.

The network grid remains unreliable due to the supply–demand gap and the damaged network infrastructure. On the upside, distributed renewable energy solutions, such as small-scale solar PV and battery storage, can provide reliable power supply options to households, communities, and businesses. Many industrial and commercial customers already had captive diesel generators before the military takeover to ensure electricity supply in the event of power outages. The diesel price has increased over three times since early 2021 making the cost of generation from such diesel generators significantly higher. Renewable energy-based solutions are becoming more cost competitive in many countries**.**

Developing a market for distributed renewable energy requires important considerations, including awareness raising among potential customers. Stronger domestic supply chains should be developed. Importing renewable energy equipment could be promoted through tax and duty exemptions. The financial sector could provide financial support to end users and suppliers to help pay high upfront capital over time. There are private sector companies that have been working on mini-grids and standalone solar home systems in the effort toward national electrification. They are good candidates to expand the domestic supply chain for distributed renewable energy solutions by leveraging knowledge and experience in renewable energy. The recent Myanmar Firm Monitoring Survey shows that many enterprise customers have captive diesel generators but only a fraction are aware of the renewable energy alternatives and their financial viability.

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