Policy and Regulatory Environment for Utility-Scale Energy Storage: Bangladesh

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National Renewable Energy Laboratory

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Preface

This report—Policy and Regulatory Environment for Utility-Scale Energy Storage: Bangladesh—is part of a series investigating the potential for utility-scale energy storage in South Asia. This report, focused on Bangladesh, is the second in a series of country-specific evaluations of policy and regulatory environments for energy storage in the region. These evaluations apply the previously developed Energy Storage Readiness Assessment to evaluate the policy and regulatory environment for energy storage in each country and provide insights into the opportunities and barriers related to energy storage growth and deployment. A similar assessment is already complete for India and a forthcoming report will expand this analysis to Nepal.

Each of these policy and regulatory evaluations of countries in South Asia includes a complementary techno-economic analysis focused on better understanding the drivers of energy storage investments in the region. Using NREL's power system planning and operational models of South Asia, these analyses identify potential storage applications and growth opportunities under various cost, policy, and demand growth scenarios. In addition, the regulatory and policy barriers and incentive mechanisms identified in the Energy Storage Readiness Assessments are incorporated into the modeling to enhance understanding of how they impact energy storage deployment and operation.

Together these studies will inform the applications and value of energy storage for power systems in South Asia, and policy and regulatory pathways to realize this value. The results of these collaborations are available at https://www.nrel.gov/international/energy-storage-south-asia.html.

Acknowledgments

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List of Acronyms

AVR	automatic voltage regulator
BERC	Bangladesh Energy Regulatory Commission
BIPPA	Bangladesh Independent Power Producers’ Association
BPDB	Bangladesh Power Development Board
FERC	Federal Energy Regulatory Commission
FTM	front-of-the-meter
FY	fiscal year
GOB	Government of Bangladesh
HFO	heavy fuel oil
IEX	Indian Energy Exchange
IPP	independent power producer
KPI	key performance indicator
LNG	liquified natural gas
MPEMR	Ministry of Power, Energy, and Mineral Resources
NLDC	National Load Dispatch Centre
NREL	National Renewable Energy Laboratory
NYSERDA	New York State Energy Research and Development Authority
PGCB	Power Grid Company of Bangladesh
PPA	power purchase agreement
PSH	pumped storage hydropower
PSMP	Power System Master Plan
SREDA	Sustainable and Renewable Energy Development Authority
VRE	variable renewable energy

Executive Summary

Bangladesh has experienced significant economic growth and poverty reduction over the past several decades. Recognizing the central role electricity plays in economic development, the Government of Bangladesh (GOB) has established policies to accelerate the growth of the electric power sector. The Bangladesh power grid is transforming into one marked by declining reliance on domestic natural gas reserves and oil-based rental power plants, increasing renewable energy contribution, and shifting demand patterns.

The GOB is now reconsidering its prior plans to increase the share of coal capacity in the generation mix to meet demand, shifting its focus instead to electricity imports from neighboring countries, nuclear generation, liquified natural gas imports, and domestic renewable resources such as wind and solar (Haque 2020).

However, investments in the transmission and distribution system, as well as ancillary services, have not kept pace with investments in generation resources over the past decade. Thus, Bangladesh electricity consumers still experience outages and poor power quality despite adequate installed capacity. On the demand side, population growth and industrialization have fueled steady growth in electricity consumption as efforts to expand access to electricity enabled near-universal electricity access by mid-2020. The combined changes in the mix of generation resources and patterns of electricity demand present new challenges and opportunities in operating and maintaining a reliable power system.

Energy storage has the potential to help meet these challenges and accelerate Bangladesh's energy transition. Declining costs for some energy storage technologies make them increasingly cost-effective solutions to provide a wide range of grid services. Previous analyses of energy storage in the region have identified several potential applications for storage at the bulk system level, including energy arbitrage, ancillary services, and transmission network support. The potential for storage to meet these needs depends on many factors, including physical characteristics of the power system and the policy and regulatory environments in which these energy storage assets would operate.

This report applies an Energy Storage Readiness Assessment[1] the National Renewable Energy Laboratory developed for policy makers and regulators to identify priority areas of focus as they continue to develop the appropriate suite of policies, programs, and regulations to enable storage deployment. This assessment uses a simple evaluation scheme (Figure ES-1) to identify the barriers and opportunities for utility-scale energy storage within Bangladesh's policy and regulatory environment.

[1] For more information on the Energy Storage Readiness Assessment, see (Rose, Koebrich et al. 2020).

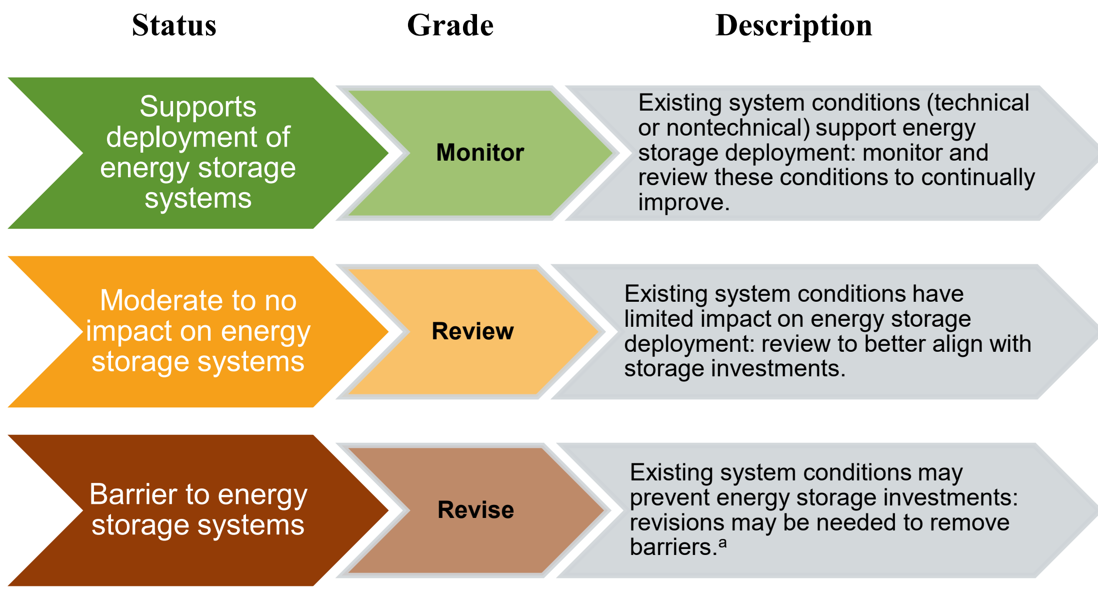

Figure ES-1. Evaluation scheme for Energy Storage Readiness Assessment

[a] Revisions may not be recommended for system characteristics where conditions that are good for the overall system (i.e., high levels of system flexibility and reliability) may not support energy storage investments.

Table ES-1 summarizes the results of the Energy Storage Readiness Assessment for Bangladesh. In general, there are technical and economic opportunities for energy storage to provide peak demand and ancillary services (green), and although policy and regulatory frameworks are largely moderate (yellow) or unsupportive (red), this is largely due to an absence of storage considerations in current frameworks rather than poorly designed energy storage policies or rules.

Topic	No.	Criteria	Assessment	Notes
System Characteristics	1	Low or decreasing load factor in electricity demand		Load factors are expected to increase
	2	Inadequate or costly provision of ancillary services		Supply of ancillary services has been inadequate to meet system requirements
	3	Inadequate or costly supply options during peak demand periods		Storage is increasingly cost-effective with existing fossil-fuel sources and imports to meet peak demand
	4	Increasing levels of transmission congestion		Storage can provide targeted assistance but will not replace or defer the need for network upgrades to relieve congestion
	5	Proposed network upgrades with low anticipated utilization		Proposed upgrades anticipated to have high utilization
	6	Low flexibility in the generation mix		Adequate sources of flexibility but future needs are uncertain
	7	Increasing curtailment of variable renewable energy (VRE)		No curtailment of VRE to date, but integration challenges may emerge as country pursues high renewable energy goals
Policy	8	Inclusion of storage in energy policy and master plan		No clear or consistent policy vision for energy storage

Topic	No.	Criteria	Assessment	Notes
	9	Targets for storage deployment		No targets for utility-scale storage
	10	Energy strategy promotes operational flexibility		No initiatives focused on system flexibility needs or incentives for storage to provide system flexibility
	11	Support organized knowledge sharing and delivery for scale-up and replication		No initiatives or organizations focused on promoting energy storage
	12	Domestic industrial policy supports storage manufacturing		No support to storage or energy sector in industrial policy
	13	Targeted support to early adopters		No support programs in place for storage technologies
Regulation	14	Utilities and private developers allowed to make storage investments		Only pumped storage hydropower (PSH) projects able to obtain license to provide grid services
	15	Interconnection processes give storage the right to interconnect and obtain transmission service		Only PSH and storage connected to RE projects are explicitly included in connection code
	16	Promotion of high-quality standardized storage technologies through safety standards		No safety standards in place or underway
	17	Operating requirements for fast-responding assets		Only PSH is eligible to provide most services
	18	Electricity services charges reflect value of and increase price transparency for energy services		Tariff updates better reflect system value; unclear whether supply payments match system needs
	19	Storage able to compete with other grid assets to provide multiple services		Opportunities limited to PSH and hybrid projects
	20	Storage able to receive revenue for providing multiple services		No compensation for services beyond power provision

Table ES-1. Results of Readiness Assessment for Bangladesh

Note: Green: supports storage deployment; Yellow: moderate to no impact on storage; Red: barrier to storage

The technical system characteristics of the Bangladesh power system are favorable for energy storage to reduce the cost of supply during peak demand periods and improve system reliability. Bangladesh's energy policy framework does not articulate a clear vision for energy storage in the country. Existing planning activities can inform the development of a clear policy framework for energy storage that addresses the many services that storage can provide as well as the full range of storage technologies available. Existing regulations restrict storage—particularly nonhydro storage—from providing services or earning revenue for those services. These rules present a barrier to identifying and maximizing the cost-effective value of storage investments.

As Bangladesh continues to expand its power sector, energy storage technologies can contribute to meet evolving system needs for flexibility and reliability. The country has successfully used policy and regulatory reform to expand access to electricity and increase electricity supply. Similar comprehensive reforms can enable economically viable storage technologies to meet emerging needs.

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1 Introduction and Background

The electric power sector in Bangladesh is transforming into one marked by declining reliance on domestic natural gas reserves and oil-based rental power plants, increasing renewable energy contribution, shifting demand patterns, and a greater focus on electricity imports from neighboring countries. The combined changes in the mix of generation resources and patterns of electricity demand present new challenges and opportunities in operating and maintaining a reliable power system.

Energy storage has the potential to help meet these challenges by managing fluctuations in electricity supply, maximizing the use of electricity imports, and providing ancillary services. Declining costs for some energy storage technologies make energy storage an increasingly cost-effective option to provide these valuable benefits. However, the potential for energy storage deployment on the grid depends on many factors, including the physical characteristics of the power system and the policy and regulatory environments in which these energy storage assets would operate.

This report was prepared by the National Renewable Energy Laboratory (NREL) with support from the U.S. Department of State to inform a broader dialogue around the future direction of Bangladesh's approach to enabling energy storage investments. This report applies an Energy Storage Readiness Assessment[2] developed by NREL to assist policy makers and regulators in identifying priority areas for focus as they continue to develop the appropriate suite of policies, programs, and regulations to enable energy storage deployment.

This assessment aims to identify the barriers and opportunities for utility-scale energy storage within Bangladesh's policy and regulatory environment. As such, the report does not address applications for distributed energy storage[3] (i.e., connected to the low- and medium-voltage networks), rural grid or stand-alone systems, or electric mobility. Importantly, the report does not inform whether energy storage is the best solution, among a wide range of possible technical and nontechnical interventions, to meet system needs.

1.1 Bangladesh's Changing Energy Landscape

Bangladesh has experienced significant economic growth and poverty reduction over the past several decades. The country has achieved its goal of reaching middle-income status by its 50th birthday in 2021, and its Vision 2041 strategic plan includes an intention to reach high-income status by 2041 (Government of Bangladesh 2020).

Recognizing the central role electricity plays in economic development, the Government of Bangladesh (GOB) has established policies to accelerate the growth of the electric power sector. These initiatives focus on encouraging more private sector investments in generation capacity and diversifying the country's electricity supply away from domestic natural gas reserves (Haque

[2] For more information on the Readiness Assessment, see (Rose, Koebrich, et al. 2020).
[3] See (Zinaman, Bowen, and Aznar 2020) for a detailed discussion of policy and regulatory design of distributed energy plus storage systems.

2020). This strategy succeeded in increasing the country's electricity supply and investments from the private sector.

As of June 2020, the total capacity reached 20,800 MW—up from 5,800 MW in 2010—and the private sector share of generation capacity reached 45% (BPDB 2020). Most of the added capacity over this period is from diesel and fuel oil rental power plants. These technologies were selected because they can be commissioned quickly. However, they are ultimately more expensive to run than conventional gas, coal, or hydropower plants. Due to the higher operating expenses, as well as significant capacity payments to idle units, the GOB plans to phase out rental power plants by 2024 (Dhaka Tribune 2021a).

Meanwhile no significant progress has been made on intermediate and long-term projects based on coal and liquefied natural gas (LNG) over the past few years. In fact, the GOB is now rethinking its prior plans to increase the share of coal capacity in the generation mix after years of slow progress on planned projects and cost reductions among other technologies—primarily renewables—reduced the economic viability of coal generation. In fact, the Ministry of Power, Energy and Mineral Resources (MPEMR) has already sought approval from the prime minister to convert 13 planned large coal power projects (out of 18 ongoing) to LNG-based plants.

Increased use of electricity imports and renewable energy also plays a central role in the country's long-term power sector strategy. In June 2020, import capacity from India reached 1,160 MW. The GOB plans to further expand its import capacity to 12,000 MW by 2041, including imports from Bhutan and Nepal as well as India. Bangladesh's first nuclear power plant, located in Rooppur, is also under construction, with the first and second reactors scheduled to come online in 2023 and 2024, respectively (World Nuclear Association 2021). Furthermore, in June 2021 the MPEMR minister announced a target to generate 40% of electricity from renewable sources by 2041.

On the demand side, population growth and industrialization have fueled steady growth in electricity consumption as concurrent efforts to expand access to electricity have achieved near-universal electricity access. As of June 2020, 97% of the population had access to electricity, nearing the government's target of universal access by 2021 (BPDB 2020). Domestic customers are the largest consumer group, accounting for 57% of retail electricity consumption nationwide in 2019–2020.

Looking forward, further economic development is expected to drive simultaneous growth in overall electricity demand and shifts in the daily patterns of demand (MPEMR 2016). Demand is expected to continue growing 9% annually through 2035, and peak demand is expected to shift from evening to daytime hours as the share of electricity demand from the industrial sector increases. Actual demand growth may be slower than official forecasts. For example, estimated peak demand for 2019–2020 was forecast to reach 17,300 MW; the forecast was later reduced 15,800 MW. Actual peak demand only reached 12,900 MW, 22% lower than the lowest official forecast, and 14% lower than the "Low Case" demand forecast (Haque 2020; MPEMR 2016).

Even though expansion of the power sector has been a priority for the GOB, the country now faces a paradoxical problem of having to implement rolling blackouts for consumers during summer months while a large portion of the generation fleet sits idle. The cause is inadequate investments in the transmission and distribution networks. These networks were not expanded in line with growth in the generation sector. As a result, in 2020 more than 44% of generation capacity remains unutilized, even during peak demand season when customers are experiencing load shedding (Haque 2020).

The errors in the country's demand forecast and a lack of coordination among generation, transmission, and distribution sectors results in an uncertain investment climate for power plant developers and poor reliability for consumers.

1.2 The Role of Energy Storage in Bangladesh's Energy Strategy

Energy storage has the potential to help meet the challenges in Bangladesh's power sector. Previous analyses of energy storage in the region have identified several potential applications for storage at the bulk system level. Table 1 shows the range of services identified and the timescale at which these services would be provided.[4]

[4] For further discussion on the services energy storage can provide at the bulk system level, see (Rose, Koebrich et al. 2020).

Table 1. Types of Services Energy Storage Can Provide at Bulk-System Level

Type of Service	Description	Timescales Text block: response time Shaded area: response duration mSec / Sec / Min / Hr / Day	Previous Analysis
Energy and Capacity	Effectively increase available load during periods with excess generation for peak demand management and reduction of renewable energy curtailment	Energy Arbitrage	(IESA 2019; CEA 2020; BNEF 2019; CERC 2017; Rose, Chernyakhovskiy et al. 2020)
	Stabilize net electricity demand to minimize thermal unit ramping and cycling and minimize errors in renewable energy and demand forecasts	Load Following	(BNEF 2019; CERC 2017)
	Provide capacity to meet generation requirements during peak loading periods and contingency events	Resource Adequacy	(CERC 2017; Rose, Chernyakhovskiy et al. 2020)
Ancillary Services	Provide power to maintain generation-load balance and prevent frequency fluctuations	Frequency Regulation	(IESA 2019; IEA 2020; CERC 2017)
	Inject or absorb incremental voltage to maintain voltage stability on the transmission system	Voltage Regulation	(CERC 2017)
	Provide immediate response to maintain electricity output during contingency events	Spinning Reserve	CERC 2017; Rose, Chernyakhovskiy et al. 2020)
	Maintain electricity output during contingency events within a short time period	Nonspinning Reserve	(CERC 2017)
	Start main turbine of grid-connected generator, or feed power into the grid so other plants can start up and restore power	Black Start	(CERC 2017)
Transmission	Provide extra capacity to meet anticipated load growth for the purpose of delaying, reducing, or avoiding transmission system investments	Upgrade Deferral	(IESA 2019; IEA 2020; CERC 2017; Rose, Chernyakhovskiy et al. 2020)
	Absorb power to reduce network congestion	Congestion Management	(IEA 2020; CERC 2017)

There are several technologies under consideration to provide these services. **Pumped storage hydro** (PSH) is the primary form of energy storage in the region. Bangladesh currently has no PSH facilities, but several potential sites have been evaluated (MPEMR 2016). The Bangladesh Power System Master Plan (PSMP) 2016 includes a goal to commission the country's first PSH project by 2030. However, the plan notes that several barriers to developing PSH persist, including limited survey data and difficulty acquiring land due to local opposition to hydropower development.

More recently, **battery technologies** are being piloted globally to serve a wide range of grid applications. Batteries can respond to signals to charge or discharge in less than a second, making them suitable for fast-response grid stability services such as frequency regulation. They can also be scaled to meet large demand needs by configuring multiple batteries in parallel with a discharge duration of minutes to hours, enabling them to provide longer-duration services such as resource adequacy, energy arbitrage, and load following. In Bangladesh, battery storage is primarily mentioned in the context of integrating renewable energy as the contribution from technologies such as solar photovoltaic (PV) increases in the long term. There are no utility-scale battery storage projects underway.

Lithium-ion batteries are the most widely used battery storage option today and control more than 90% of the global utility-scale battery storage market (Mongird et al. 2019). Compared to other battery technologies, lithium-ion batteries have a high energy density, are lightweight, and are less expensive. These cost and performance advantages make lithium-ion the primary battery storage option being deployed globally.

Demand for lithium-ion batteries in Bangladesh is expected to increase for transportation and power system applications. For example, in an effort to increase the uptake of electric vehicles, the GOB moved to legalize electric three-wheelers in 2019 (Islam 2019). It is believed that there are already around 100,000 such vehicles operating in the country. In the power sector, lithium-ion batteries are the leading technology option to pair with renewable energy facilities in the long term to manage variability (Chowdhury 2020).

Lead acid batteries were among the first battery technologies used for energy storage; however, compared to lithium-ion batteries, they have a low energy density and shorter cycle and calendar life. As a result, lead acid batteries are increasingly limited to backup power or remote grid applications. Recent research on advanced lead acid batteries has sought to overcome the issue of poor life cycle and slow charging rates. Lead acid batteries were primarily used as a backup power source for grid-connected customers or as part of a solar home system for off-grid customers. However, lithium-ion batteries have taken over the market share for these applications (Podder and Khan 2016).

Flow batteries present an emerging alternative to lithium-ion batteries. This technology stores energy directly in the electrolyte solution, resulting in a longer cycle life and faster response times. Flow batteries are in the early stages of commercialization compared to other battery technologies; however, their longer life cycles, higher depth of discharge, and easy scalability offer advantages over other battery chemistries (Mongird et al. 2019). There are no existing or proposed flow battery projects in Bangladesh.

The Energy Storage Market in the United States

Energy storage has been growing rapidly in the United States, driven by falling technology costs and public policies. While PSH still accounts for 95% of front-of-the-meter (FTM) energy storage capacity in the United States, more than 1 GW of nonhydro battery capacity has been added to date. The share of nonhydro FTM energy storage investments is expected to increase further, with an additional 81 GW projected to be added by 2025 (Wood Mackenzie 2019). Cost declines for FTM systems are expected to continue in the coming years. System prices for long- and medium-duration FTM systems are expected to decline by 15% from 2019 to 2021.

The growing contribution from renewables in states across the United States has been a key driver for the storage industry. Thirty-seven states have either legally binding renewable portfolio standards or voluntary renewables goals (NCSL 2020). Seven states have also set targets or mandates explicitly for storage (Burwen 2020). Many utilities are installing storage through requests for proposals for capacity fulfillment or as an add-on to solar and wind projects. Other states encourage storage through pilot installations. On the federal level, attempts to pass storage incentives have so far stalled, although storage projects charged by renewables for >75% of the time can take advantage of existing investment tax credits as well as a Modified Accelerated Cost Recovery System depreciation reduction (Elgqvist, Anderson, and Settle 2018).

As investments increase, regulators at the federal and state levels are responding to remove barriers for energy storage and better capture the unique features of storage technologies. Federal Energy Regulatory Commission (FERC) Order 841 directs U.S. markets to create rules for energy storage to participate in wholesale, capacity, and ancillary service markets on a nondiscriminatory basis alongside other assets (FERC 2018). While FERC Order 841 seeks to remove barriers for energy storage, it gives each market discretion to design their own rules for compliance, thus allowing for multiple solutions.

Other regulations seek to improve existing compensation mechanisms to better capture the value energy storage and other technologies provide to the system. For instance, FERC Order 755 requires U.S. markets to adopt a two-part market-based compensation mechanism for frequency regulation services: a capacity payment that reflects the opportunity cost of not using the resource for some other service and a market-based performance payment that rewards faster-ramping resources (FERC 2011). In the PJM territory, this led to a tripling of fast-moving resources available for frequency regulation (Tweed 2013). Because these resources can respond to signals more quickly and accurately, PJM was able to lower its regulation requirements.

In Texas, the state legislature amended a rule to allow municipal utilities and electric cooperatives to own energy storage facilities without registering as a power generator. This change enables utilities to use storage facilities to defer or avoid the need for network investments (Mai 2019).

The United States is in a familiarization phase with energy storage. Policy programs have been instrumental in directing the scope and scale of storage deployment, while regulatory reforms have focused on establishing a level playing field for energy storage to provide grid services and be compensated for those services without being overly prescriptive.

2 Energy Storage Readiness Assessment

The Energy Storage Readiness Assessment developed by NREL identifies 20 technical and nontechnical factors that enable energy storage investments and operation (Rose, Koebrich et al. 2020). These factors are grouped into three topics: System Characteristics, Policy, and Regulation.

Table 2. Components of the Energy Storage Readiness Assessment

Topic	No.	Criteria
System Characteristics	1	Low or decreasing load factor in electricity demand
	2	Inadequate or costly provision of ancillary services
	3	Inadequate or costly supply options during peak demand periods
	4	Increasing levels of transmission congestion
	5	Proposed network upgrades with low anticipated utilization
	6	Low flexibility in the generation mix
	7	Increasing VRE curtailment
Policy	8	Storage included in energy policy and master plan
	9	Targets for storage deployment
	10	Energy strategy promotes operational flexibility
	11	Support organized knowledge sharing and delivery for scale-up and replication
	12	Domestic industrial policy supporting storage manufacturing
	13	Targeted support to early adopters
Regulation	14	Utilities and private developers allowed to make storage investments
	15	Interconnection processes give storage the right to interconnect and obtain transmission service
	16	Promotion of high-quality standardized storage technologies through safety standards
	17	Operating requirements for fast-responding assets
	18	Electricity services charges reflect value of and increase price transparency for energy services
	19	Storage able to compete with other grid assets to provide multiple services
	20	Storage able to receive revenue for providing multiple services

The system characteristics capture the technical aspects that describe the power system, such as changes in load shape, adequacy in capacity and ancillary services, and utilization of the transmission network. This section identifies operational and planning challenges that commonly afflict rapidly changing grids where energy storage could provide solutions. These characteristics can help identify whether there is a technical or economic need for utility-scale energy storage.

The policy criteria cover the set of guidelines that direct the scope and scale of storage deployment. These topics span early-stage exploration into the feasibility of integrating energy storage through establishing deployment targets and support programs to grow the industry, both from the supply and demand sides. The goal of these activities is to accelerate the identification and implementation of appropriate energy storage solutions should the GOB decide to do so.

The regulatory topics capture the set of rules necessary to define how energy storage technologies should be treated. These include rules regarding ownership and planning, as well as operational practices, tariffs, and safety standards. The regulations could enable energy storage to compete on a nondiscriminatory basis with other grid assets to provide grid services and be compensated for those services.

To complete the Energy Storage Readiness Assessment, each criterion is assigned a grade based on the evaluation scheme in Figure 1.

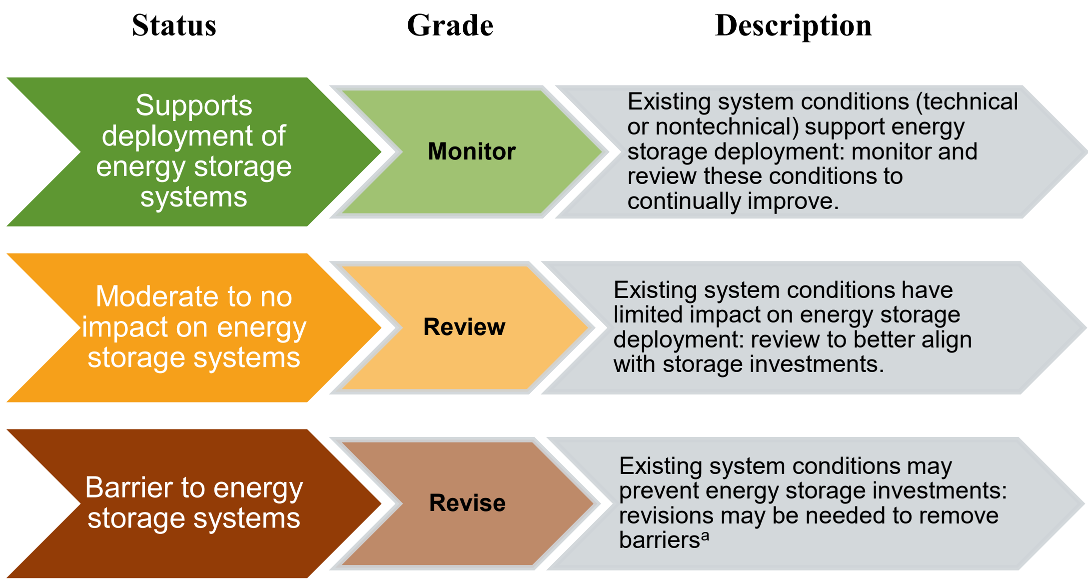

Figure 1. Evaluation scheme for Energy Storage Readiness Assessments

[a] Revisions may not be recommended for system characteristics where conditions that are good for the overall system (i.e., high levels of system flexibility and reliability) may not support energy storage investments.

The "Monitor" grade indicates existing system conditions support energy storage deployment. These conditions should be monitored to identify areas for continued improvement. In cases where system conditions have limited impact—positive or negative—on energy storage deployment, a grade of "Review" is given. This indicates the need to review and, if desirable, update policy or regulatory frameworks to enable more effective energy storage deployment. Finally, criteria that present a barrier to energy storage are given a grade of "Revise," indicating action may be required to remove existing conditions that may be preventing investments in energy storage.

This assessment is designed to allow policy makers and regulators to quickly gauge how well existing policy and regulatory frameworks support energy storage. As such, it is not designed to recommend specific policy or regulatory solutions but rather to identify priority areas for focus. It is also not designed to inform whether energy storage is the best solution among other possible technical and nontechnical interventions to meet system needs. Furthermore, a given system may need to be reassessed periodically as system conditions change.

3 Application of the Readiness Assessment: Bangladesh

As the GOB increasingly emphasizes the need for more efficient use of resources and utility-scale renewable energy, policy makers and regulators will benefit from examining the appropriate suite of policies, programs, and regulations to enable complementary energy storage investments to maximize the value of both renewables and storage. In this section, we apply the Energy Storage Readiness Assessment to Bangladesh's power system to inform this dialogue and assist policy makers and regulators in identifying priority areas for focus moving forward.

3.1 Overview of Bangladesh's Power Sector

At the national level, Bangladesh's energy sector is governed by the MPEMR. Within MPEMR's Power Division, the Power Cell is responsible for implementing various power sector reform activities, such as developing the Power System Master Plans. The latest PSMP was released in 2016, followed by an updated revision in 2018. The next version is expected in 2021 but has been delayed due to the COVID-19 pandemic. The Sustainable and Renewable Energy Development Authority (SREDA), established by law in 2012, is also housed within this division. SREDA is tasked with all renewable energy and energy efficiency efforts in Bangladesh, such as capacity building, launching pilot projects, attracting investors, raising awareness, labeling products, and investing in research and development.

In 2003 the Bangladesh Energy Regulatory Commission (BERC) was established with goals to promote competition in the energy sector, protect consumer interests, promote transparency in management and tariff setting, and create an environment suitable for private investment. BERC determines wholesale and retail prices for electricity, gas, and petroleum products; grants licenses to power system participants; and implements codes and standards to ensure quality in the energy sector.

The Power Grid Company of Bangladesh (PGCB) owns and operates the national bulk power grid. Its subdivision, the National Load Dispatch Center (NLDC), monitors and controls network operations and the dispatch of power. Long-term contracts or power purchase agreements (PPAs) are the sole mechanism for energy sales, as there are no wholesale electricity markets in Bangladesh. The Bangladesh Power Development Board (BPDB) is the single buyer in this system, purchasing power from its own generation fleet, other state-owned power generation companies, and independent power producers (IPPs), and via imports. BPDB, which is itself responsible for the distribution system in all urban areas of Bangladesh except for greater Dhaka, then sells this power at BERC-regulated wholesale rates to the state-owned utilities responsible for distribution to retail customers.

The Dhaka Power Distribution Company covers most of the greater Dhaka area, the Dhaka Electric Supply Company covers the northern parts of the city, the West Zone Power Distribution Company covers the western regions such as Khulna and Barisal, and the Bangladesh Rural Electrification Board covers the distribution of electricity in rural zones.

3.2 Assessment Summary

Table 3 summarizes the results of the Energy Storage Readiness Assessment for Bangladesh. Subsequent sections present a detailed analysis of how the results are obtained for each criterion. In general, the technical characteristics of the Bangladesh power system are somewhat favorable for energy storage, while the policy and regulatory frameworks are largely unsupportive; however, this is mostly due to an absence of storage considerations in current frameworks rather than poorly designed energy storage policies or rules.

Table 3. Results of Energy Storage Readiness Assessment for Bangladesh

Topic	No.	Criteria	Assessment	Notes
System Characteristics	1	Low or decreasing load factor in electricity demand		Load factors are expected to increase
	2	Inadequate or costly provision of ancillary services		Supply of ancillary services has been inadequate to meet system requirements
	3	Inadequate or costly supply options during peak demand periods		Storage is increasingly cost-effective with existing fossil-fuel sources and imports to meet peak demand
	4	Increasing levels of transmission congestion		Storage can provide targeted assistance but will not replace or defer the need for network upgrades to relieve congestion
	5	Proposed network upgrades with low anticipated utilization		Proposed upgrades anticipated to have high utilization
	6	Low flexibility in the generation mix		Adequate sources of flexibility but future needs are uncertain
	7	Increasing curtailment of variable renewable energy		No curtailment of VRE to date, but integration challenges may emerge as country pursues high renewable energy goals
Policy	8	Inclusion of storage in energy policy and master plan		No clear or consistent policy vision for energy storage
	9	Targets for storage deployment		No targets for utility-scale storage
	10	Energy strategy promotes operational flexibility		No initiatives focused on system flexibility needs or incentives for storage to provide system flexibility
	11	Support organized knowledge sharing and delivery for scale-up and replication		No initiatives or organizations focused on promoting energy storage
	12	Domestic industrial policy supports storage manufacturing		No support to storage or energy sector in industrial policy
	13	Targeted support to early adopters		No support programs in place for storage technologies
Regulation	14	Utilities and private developers allowed to make storage investments		Only PSH projects able to obtain license to provide grid services
	15	Interconnection processes give storage the right to interconnect and obtain transmission service		Only PSH and storage connected to renewable energy projects are explicitly included in connection code
	16	Promotion of high-quality standardized storage technologies through safety standards		No safety standards in place or underway
	17	Operating requirements for fast-responding assets		Only PSH is eligible to provide most services
	18	Electricity services charges reflect value of and increase price transparency for energy services		Tariff updates better reflect system value; unclear if supply payments match system needs
	19	Storage able to compete with other grid assets to provide multiple services		Opportunities limited to PSH and hybrid projects
	20	Storage able to receive revenue for providing multiple services		No compensation for services beyond power provision

3.3 System Characteristics

The technical characteristics of the Bangladesh power system are somewhat favorable for energy storage. There are opportunities for energy storage to provide ancillary services and demand during peak periods, and new opportunities may emerge as the GOB pursues its renewable energy goals.

1. Low or Decreasing Load Factor in Electricity Demand Review

Load factor is a metric representing electric system utilization and is calculated by dividing the average power demand by the peak power demand during a selected period. Low load factors indicate volatility in demand and sometimes require that capital-intensive generation or transmission infrastructure be built to serve load only for a short time. MPEMR projects that load factors will increase from 60.63% in 2019 to 65.66% in 2041 in each of their three demand forecasts: high case, base case, and low case (MPEMR 2018b). From 2007 to 2020, the actual load factors in the national grid fluctuated from as high as 72.97% in 2009 to as low as 60.75% in 2019 (Figure 2).

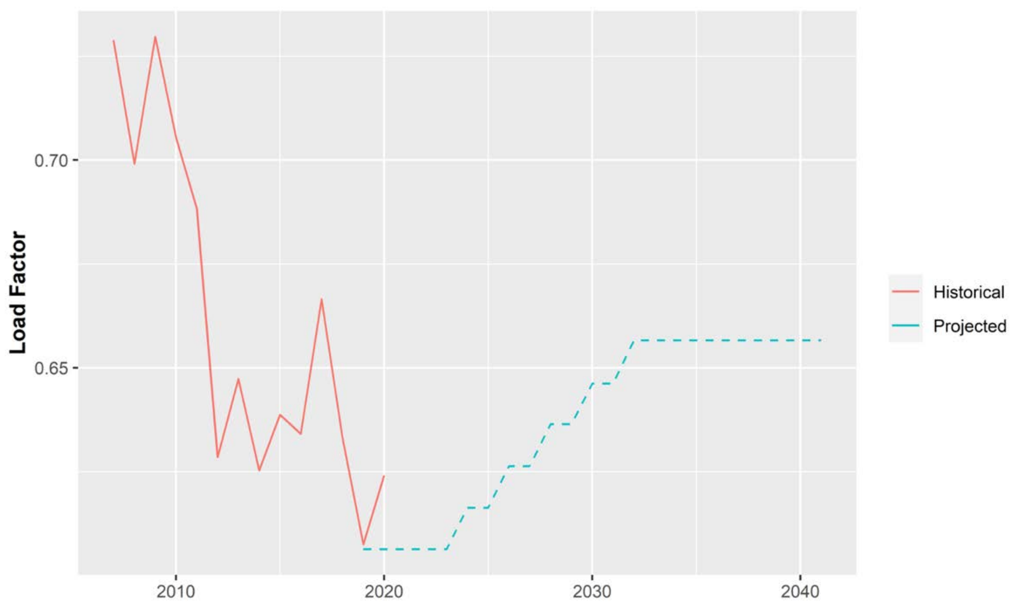

Figure 2. Historical and projected changes in load factor from 2007 through 2041 in Bangladesh grid

Source: BPDB Annual Reports (2007–2020) and (MPEMR 2018b)

The result of increasing load factors will be a flatter demand profile, with less variation between low and high demand periods, and hence greater utilization of existing and planned generation assets. The projected 5% increase in load factor over the next 20 years is based on anticipated economic growth that will result in higher levels of commercial and industrial activity. The expected impact on electricity demand is a shift from a peak demand at 20:00 in 2017, primarily driven by residential lighting, to a less pronounced peak at 13:00 by 2041. In the near term, Bangladesh might continue to see volatility in its load factor, similar to the 2007–2020 historical data, if demand growth is uneven across different sectors.

Historically, there is a seasonal trend in load factors from 2013 through 2019[5]. Although the annual load factors do not show a clear downward or upward trend during this 7-year period, load factors are generally higher in the spring and summer months and lower in the fall and winter months. This indicates that there could be seasonal opportunities for energy storage to provide load following services during the fall and winter months, which generally have more variable demand profiles.

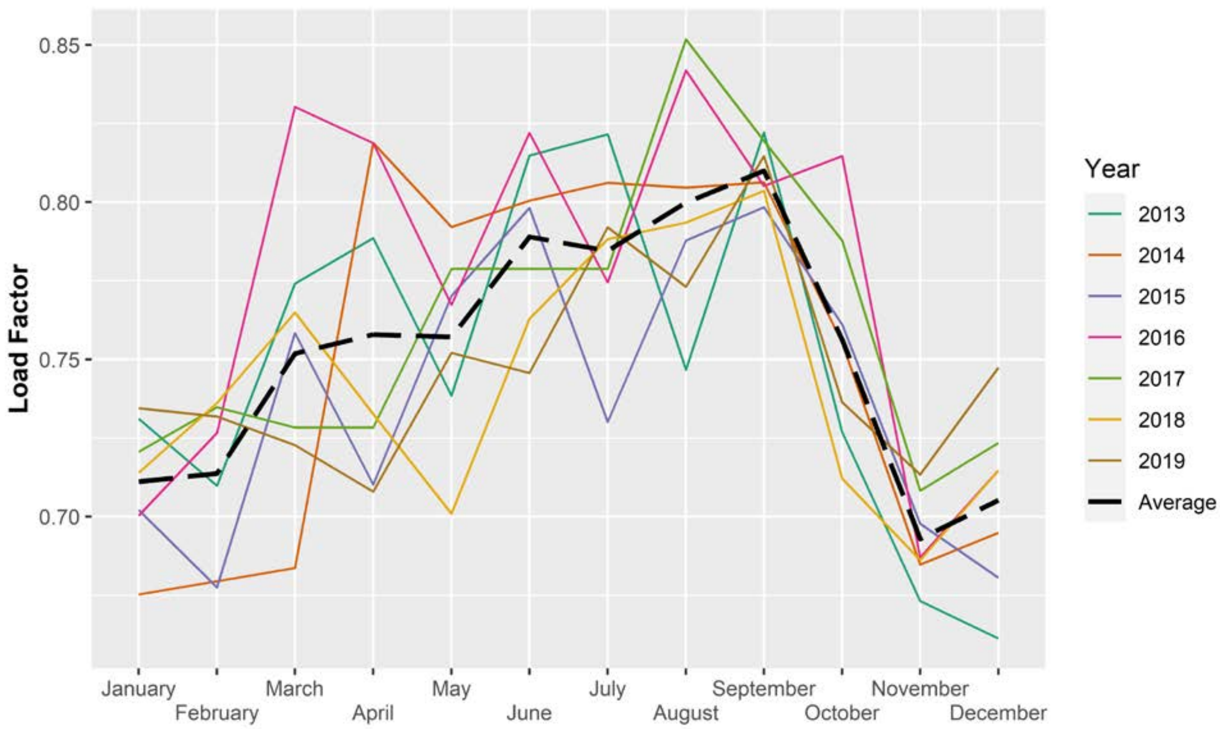

Figure 3. Variation in monthly load factors from 2013 through 2019 in Bangladesh grid

Source: PGCB Monthly Reports (January 2013–December 2019)

Energy storage technologies can be used to reduce variability in electricity demand by charging during off-peak hours and discharging during peak demand hours. This can reduce the need to build generation resources that only serve peak demand during a small fraction of the year. If the GOB achieves its objectives to increase industrial and commercial electricity demand, which typically exhibit flatter demand profiles, overall load factors may increase as forecast by MPEMR, and the opportunities for energy storage to provide this service may be limited. However, electricity demand changes from the industrial and commercial sectors may be offset by changes in consumption patterns from the residential sector such as increased use of air conditioners. There is no wholesale electricity market in Bangladesh and thus no energy arbitrage opportunities for storage exist. However, this could change if the GOB seeks to create a wholesale energy market like the Indian Energy Exchange Limited (IEX). Bangladesh could also

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[5] 2020 data is not included to exclude the effect of the COVID-19 pandemic.

participate in the IEX, as India has updated its market rules to allow participation from neighboring countries (DT Next 2020).

2. Inadequate or Costly Provision of Ancillary Services

Monitor

BERC stipulates ancillary service requirements for generators, specifically for frequency regulation, voltage regulation, operating reserves, and black start capabilities (BERC 2019). Despite these minimum provisions, the actual supply of ancillary services has been inadequate in recent years, presenting an opportunity for energy storage to play a vital role in maintaining operational reliability.

BERC seeks to maintain system frequency within the range of 49.5–50.5 Hz (50 ±0.5 Hz), with a goal of achieving a range of ±0.2 Hz by 2041 (PSMP 2016). For primary frequency control, conventional generators must be equipped with a fast-acting speed governor that can automatically respond to normal variations in system frequency by triggering increases or decreases in the output of the generator. The NLDC will also provide instructions to generators for secondary and tertiary frequency control (BERC 2019).

Prior to 2017, frequency was only controlled via manual dispatch instructions from the NLDC, and no generators were equipped with primary frequency control capabilities (George and Ong 2017). Furthermore, over the last decade, generators have not been able to retain adequate reserve capacity for provision of secondary or tertiary frequency control, resulting in frequency fluctuations exceeding ±1 Hz that have negatively impacted power system reliability (MPEMR 2016). Energy storage can provide additional frequency regulation by rapidly charging or discharging in response to control signals.

In normal operating conditions, BERC aims to keep voltage within ±5% for 400-kV lines and ±6% for 230-kV and 132-kV lines. In emergency situations, this range is expanded to ±10% for 400-kV lines and ±15% for 230-kV and 132-kV lines (BERC 2019). All generating units are required to provide primary voltage control in the form of Automatic Voltage Regulators (AVRs) to conform with the constant voltage levels specified by the NLDC. Generators are also required to communicate their reactive power reserve capabilities to the NLDC upon request, allowing the NLDC to send instructions to generators to increase or decrease their reactive power output within their specified capabilities to assist with voltage regulation when needed. In practice, system voltage is poorly maintained in the western and northern regions due to long transmission lines and a lack of generating plants (MPEMR 2016). Therefore, there is an opportunity for geographically targeted storage resources to provide fast-acting voltage regulation services and improve power quality.

As noted above, BERC also specifies that the NLDC will instruct generators to hold certain quantities of operating reserves, both spinning and nonspinning. However, the quantum of mandated reserves is unclear, and a deficiency in available capacity from thermal generators, including spinning reserves, led to frequent load shedding pre-2015 (MPEMR 2016). Compared to various energy storage technologies, these thermal generators are also limited in how quickly they can increase or decrease their power output. To recover from grid outages, BPDB is responsible for ensuring there is at least one black start generator in each discrete power island of the grid (BERC 2019). Installation of energy storage can reduce the reliance on spinning reserves from traditional generators and provide black start capabilities as well, thereby enhancing system resiliency.

Generators are not compensated for providing ancillary services via markets or contracts. MPEMR has identified PSH as a resource that can help stabilize the power system via ancillary services but also acknowledges that private development of PSH is unlikely without an ancillary service market to provide an additional revenue stream for investors (MPEMR 2016). This barrier also exists for other forms of energy storage that can provide these valuable services, such as batteries and flywheels.

3. Inadequate or Costly Supply Options During Peak Demand Periods

Monitor

Although Bangladesh currently has adequate supply options to meet peak demand, these options are costly, and load shedding still occurs. Data on load shedding during peak demand periods was analyzed from Fiscal Year (FY) 2014 through FY 2019[6]. Throughout this period, Bangladesh had adequate installed capacity to meet peak demand during the evening and daytime. As seen in Figure 5, annual peak demand in the day was matched by annual peak generation in the day for all years and annual peak demand in the evening was matched by annual peak generation in the evening for all years except FY 2014. These peak demand and generation values were consistently exceeded by installed and derated capacity, wherein derated capacity accounts for the reduction in power plant availability due to maintenance and repairs.

[6] The fiscal year in Bangladesh runs from July 1 through June 30. For example, FY 2014 starts on July 1, 2013, and ends on June 30, 2014. FY 2020 data is not included to exclude the effect of the COVID-19 pandemic.

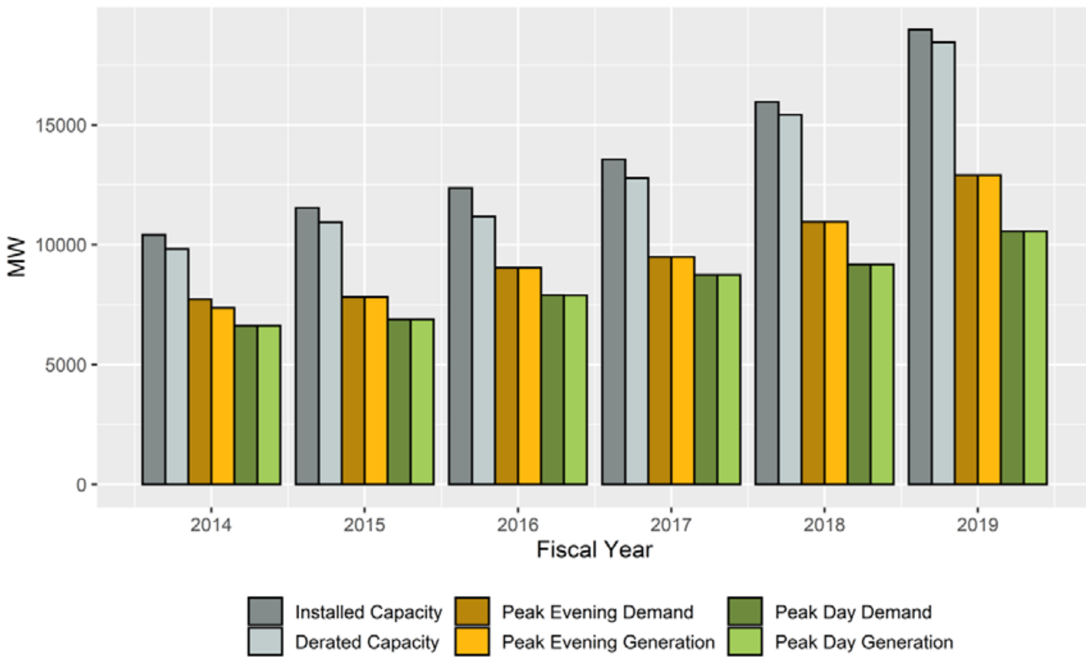

Figure 4. Installed and derated power capacity compared to peak generation and demand from FY 2014 through FY 2019 in Bangladesh grid

Source: PGCB Monthly Reports (July 2013–June 2019) and BPDB 2020). Data not available for July 2015 and December 2015.

However, despite adequate capacity, the system still experienced load shedding over the 6-year period analyzed. As shown in Figure 5, load shedding occurred during the evening and daytime peak demand periods on 31.78% and 18.90% of days, respectively, in FY 2014. By FY 2017, the number of days with load shedding fell to 12.33% (evening peak) and 0.55% (daytime peak). PGCB reported no instances of load shedding during peak demand periods in FY 2018 and FY 2019. Out of the 507 instances of load shedding during peak demand periods (evening and daytime) from FY 2014 through FY 2017, PGCB recorded only 96 (19%) as being "*Due to Generation Shortage and Gas Restriction*. The cause of the remaining 81% of events was unspecified. Although PGCB does not specify the cause of majority of recorded load-shedding events, a report by EBL Securities Ltd. states that "*Load-shedding and power failure prevails [in Bangladesh] even with significant unused capacity due to inadequate power transmission and distribution system*" (Haque 2020). Inadequate grid infrastructure was also identified by BPDB as the main reason unserved energy still exists despite adequate installed capacity (BPDB 2020).

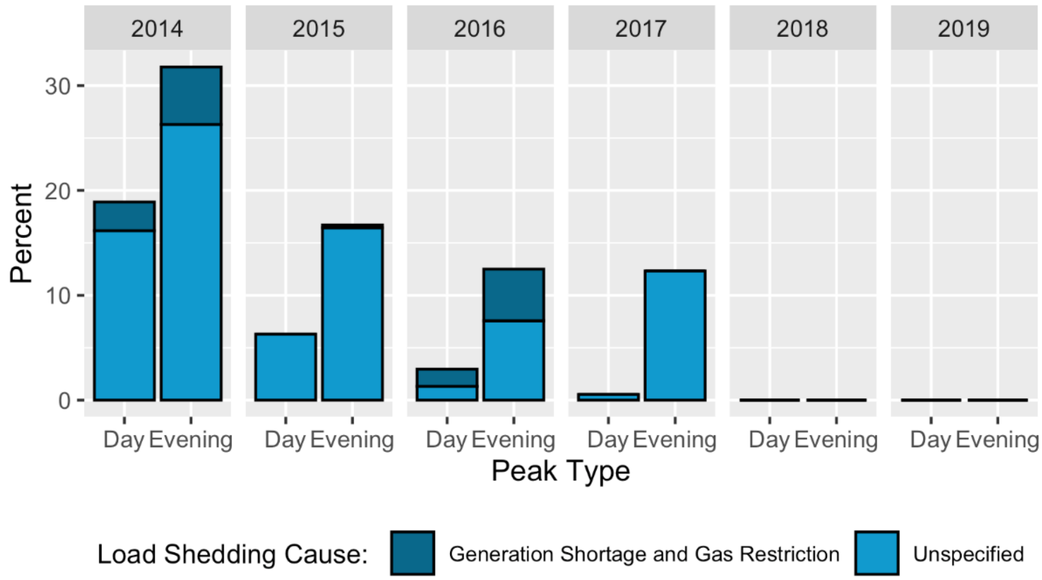

Figure 5. Percent of days with load shedding during peak day and evening demand from FY 2014 through FY 2019 in Bangladesh grid

Source: PGCB Monthly Reports (July 2013–June 2019). Data not available for July 2015 and December 2015.

Although installed capacity is adequate to meet peak demand as of this writing, electricity demand is expected to grow significantly over the next several decades, and Bangladesh currently relies on very costly supply options to meet its peak demand. Following the strategy set forth in the 2010 PSMP, BPDB has procured significant power capacity from rental and quick rental power plants to meet the rapidly growing power demand and reduce load shedding (Mujeri and Chowdhury 2013). From 2010 through 2012, 1,827 MW of rental power plants were commissioned, consisting of 967 MW of heavy fuel oil (HFO) plants, 545 MW of gas plants, and 315 MW of diesel plants. Due to retirements and expired contracts, the installed capacity of rental power plants as of June 2020 was 1,301 MW (BPDB 2020). These generators are the most expensive supply option for BPDB, followed by IPPs and imports from India (Table 4). Within BPDB's own generation portfolio, most of the peaker plants are either HFO-fired, with an average capacity factor of 8%, or diesel-fired, with an average capacity factor of 2%. As seen in Table 4, these resources have the highest average generation cost at 26.04 BDT/kWh[7] and 106.29 BDT/kWh, respectively.

Table 4. Average Generation Costs in FY 2019–FY 2020[8]

Generation Source	Average Generation Cost (BDT/kWh)
BPDB's Generation: Total	4.47
BPDB: Hydro	1.82
BPDB: Gas	3.27

[7] A Bangladeshi Taka (BDT) is equivalent to 0.86 Indian Rupee (INR) and 0.012 U.S. dollars (USD) as of 5/22/21.
[8] The average generation costs in Table 4 (BDT/kWh) include the fuel cost, variable operation and maintenance (O&M) costs, and fixed capital costs.

Generation Source	Average Generation Cost (BDT/kWh)
BPDB: Coal	6.98
BPDB: Solar	11.24
BPDB: Wind	23.29
BPDB: HFO	26.04
BPDB: Diesel	106.29
Purchase from Public Plant	3.86
Purchase from India	6.01
Purchase from IPP	7.00
Purchase from Rental	8.34

Source: (BPDB 2020)

MPEMR, in its 2016 PSMP, discussed the use of PSH to replace HFO as a peaking resource. However, battery energy storage paired with renewables presents an increasingly cost-competitive alternative to meet peak demand and avoid investments in underutilized traditional generation resources (Chowdhury 2020). These projects can also be completed on a much shorter schedule compared to PSH. In neighboring India, BloombergNEF estimates a new PV or wind power project with 1-hour battery storage is already competitive with gas power plants (BNEF 2019). The first centralized auction for renewable energy paired with energy storage in India to provide “round-the-clock” renewable power in May 2020 achieved a tariff of INR 2.9 (BDT 3.4) per kWh, significantly cheaper than the peaking resources currently used in Bangladesh. Therefore, energy storage has a prime opportunity to cost-effectively meet the country’s increasing levels of peak demand and avoid future load shedding due to inadequate generation resources.

4. Increasing Levels of Transmission Congestion

Review

The expansion of Bangladesh’s electricity grid has not kept pace with the expansion of generation plants, resulting in an increasingly congested grid. The previous section discussed the role of network congestion on supply interruptions, particularly during peak demand periods. Data on outages of transmission lines and substations was analyzed from 2013 through 2019, in which outages were classified by PGCB within one of the following categories: “Scheduled Outage” (S/O), “Emergency Outage” (E/O), or “Tripping” (T) (Figure 6). Scheduled Outages were the most frequent throughout this period (62.14%), followed by Tripping (28.10%) and Emergency Outages (9.76%). Since 2015, after PGCB started reporting outages in the Bheramara HVDC grid circle and disaggregated the Dhaka region into North and South sections outages of all types have occurred most frequently in the Dhaka North region (16.68%), followed by Comilla (15.70%), Dhaka South (14.55%), Khulna (14.18%), Bogra (13.72%), Chittagong (10.93%), and Bheramara HVDC (5.53%).

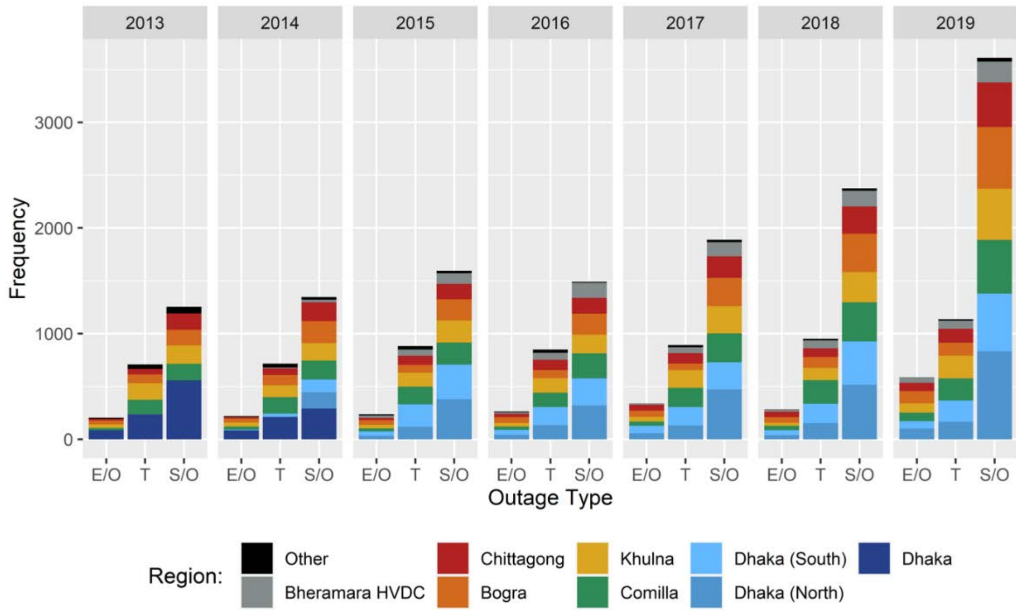

Figure 6. Aggregated transmission line and substation outages by type and region from 2013 through 2019 in Bangladesh grid

Source: PGCB Monthly Reports (January 2013–December 2019). Dhaka region divided into North and South sections and Bheramara HVDC region added starting with November 2014 report. E/O = Emergency Outage, S/O = Scheduled Outage, T = Tripping.

Although Figure 6 shows total transmission and substation outages have increased steadily from 2013 through 2019, it is important to note that the quantity of both transmission lines and substations has increased during this period as well (Table 5). However, the data show outages per circuit-km of transmission line have increased from FY 2014 through FY 2019. The same overall observation can be made for outages per MVA of substation capacity, though the trend is not as stark.

Table 5. Increase in Outages Compared to Increase in Transmission Length and Substation Capacity from FY 2014 through FY 2019 in Bangladesh Grid

Fiscal Year	Total Transmission Length (circuit-km)	Total Substation Capacity (MVA)	Total Number of Outages	Outages/Circuit-Km	Outages/MVA
2014	9,419	19,489	2,068	0.220	0.106
2015	9,610	21,559	2,454	0.255	0.114
2016	9,807	22,551	2,776	0.283	0.123
2017	10,351	26,040	2,697	0.261	0.104
2018	11,035	30,123	3,442	0.312	0.114
2019	11,650	35,802	4,465	0.383	0.125

Source: PGCB Monthly Reports (July 2013–June 2019) & PGCB Annual Report 2019–2020. "Total Transmission Length (circuit-km)" includes 400-kV, 230-kV, and 132-kV lines. "Total Substation Capacity (MVA)" includes 400/230 kV, 400/132 kV, 230/132 kV, and 132/33 kV substations but excludes the 1 HVDC substation. "Total Number of Outages" includes both transmission and substation outages.

As a short-term solution, energy storage resources can improve grid operations by absorbing or injecting power to reduce congestion and improve overall transmission utilization. As the patterns of power flows change in response to changes in demand or investments in generation and transmission assets, some energy storage technologies can be relocated when no longer needed, increasing their overall value to the grid (Bowen, Chernyakhovskiy, and Denholm 2019). For example, New York City utility Con Edison (ConEd) is piloting a mobile tractor-trailer-based 1-MW/4-MWh battery storage system that readily relocates to where it is most useful (Maloney 2017). However, the GOB will still need to significantly increase the capacity of its transmission system to meet increasing levels of demand in the coming decades. Hence, utility-scale energy storage is unlikely to completely replace or defer the need for network upgrades in the near term. Despite this, storage could play a targeted role in more congested regions of the grid where available land is particularly scare, such as the Dhaka grid circle. Historically, in regions with limited transmission capacity, rental HFO or diesel power plants were added to serve load (MPEMR 2018b). These plants can be constructed quickly but are not mobile. Moving forward, energy storage could play a similar role as the transmission system expands in Bangladesh.

5. Proposed Network Upgrades with Low Anticipated Utilization

Review

In addition to increasing generation capacity, the GOB and its partners have placed a significant emphasis on building new transmission lines and substations to avoid outages and load shedding. From FY 2014 through FY 2019, total transmission length (circuit-km) increased by 24%, and total substation capacity (MVA) increased by 84% (PGCB 2020). Additionally, 1,000 MW of new HVDC substation capacity was built. In March 2018, the World Bank approved a USD $450 million investment in Bangladesh to construct or rehabilitate 450 km of transmission lines and 9,040 MVA of substation capacity in the eastern region (World Bank 2018). In November 2019, the Asian Development Bank approved a USD $300 million loan to construct 408 km of transmission lines and 7,520 MVA of substation capacity in Greater Dhaka and western Bangladesh (ADB 2019).

Similarly, massive investments will be needed over the next two decades. By 2041, the GOB plans to increase total transmission length (circuit-km) by 216% and substation capacity (MVA) by 583% compared to FY 2019 levels (MPEMR 2018b). These projects are primarily implemented to increase system reliability, meet redundancy requirements, and mitigate unused generation capacity. These existing issues are anticipated to remain in the near future. For example, the Payra coal-fired power plant has had idle capacity even after commissioning due to a delayed transmission line connection (Nicholas 2021). Overall, the network upgrades are anticipated to have a high rate of utilization upon commissioning. Therefore, there may not be significant opportunities for energy storage to reduce investments in transmission infrastructure in the intermediate future.

6. Low Flexibility in the Generation Mix

Review

Growth in electricity demand and anticipated changes in load shape will impact the flexibility requirements of Bangladesh's power system. The MPEMR estimates the country's load shape will shift to peak during the daytime with a lower relative decline during the evening hours (MPEMR 2018).

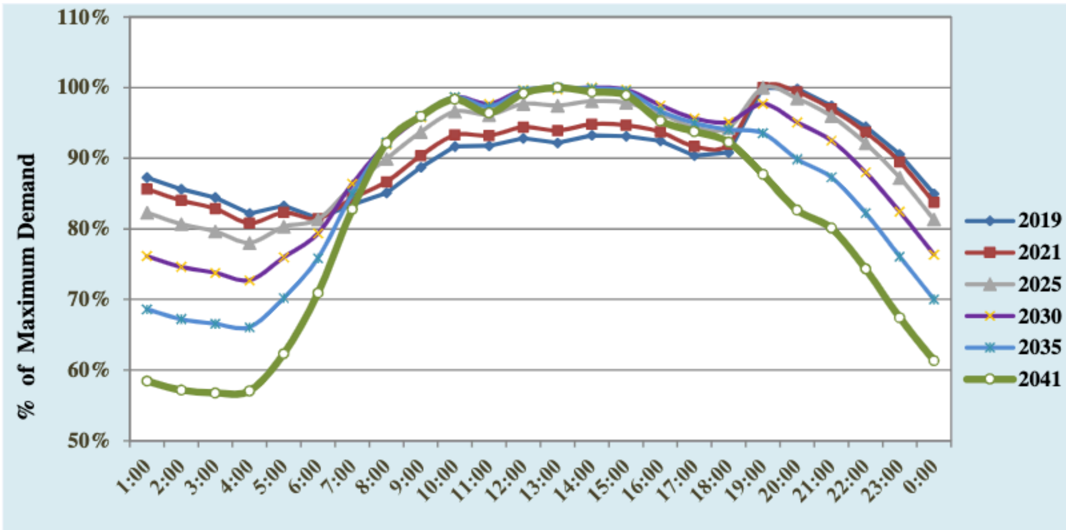

Figure 7. Estimated load curves for Bangladesh, 2017–2041

Source: (MPEMR 2018b)

Using these estimates for how the load curves will evolve with MPEMR's peak demand forecast, we estimate the anticipated hourly ramping needs of the system for select years (Figure 9).

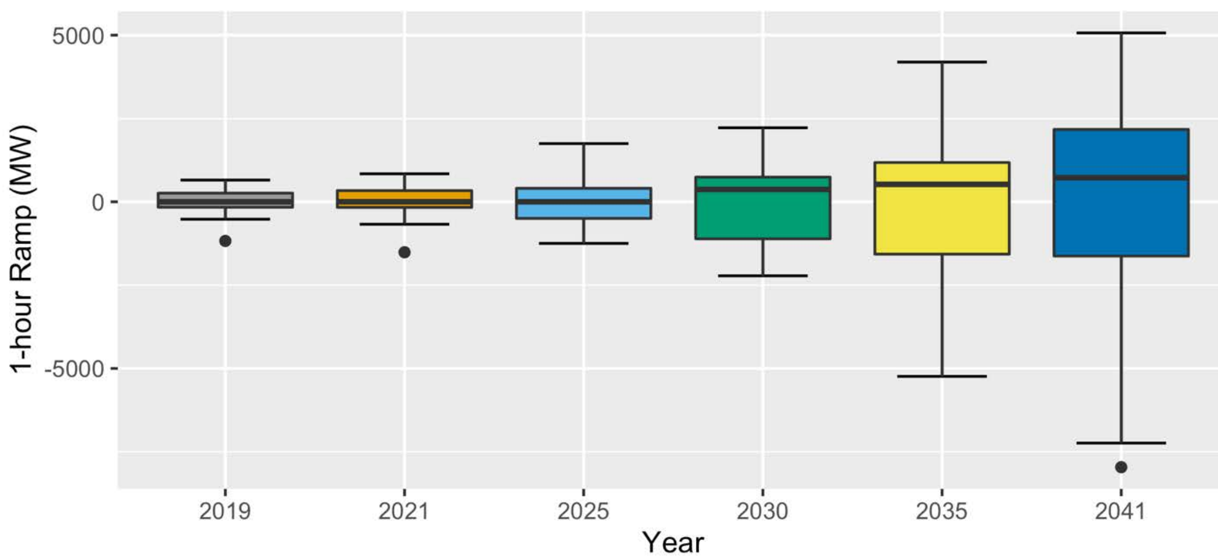

Figure 8. Estimated hourly ramping requirements of Bangladesh power system, 2019–2041

The hourly ramping requirements for the system are anticipated to increase from an average of 271 MW per hour (up or down) in 2019 to more than 2,700 MW per hour by 2041. The existing generation fleet and planned additions outlined in the PSMP consist primarily of gas, coal, fuel oil, and nuclear plants have adequate flexibility to meet the system's flexibility needs. However, inadequate capacity in the transmission and distribution networks to facilitate power flows may prevent some flexible generators from contributing to system ramping needs.

It is also unclear how the country's target to achieve 40% of generation from renewable energy will impact the system's flexibility needs. For example, a large contribution of solar generation may reduce the future system's daytime peak demand and ramping needs. On the other hand, large contribution from variable renewables may also introduce more short-term fluctuations in power supplies that must be balanced by other generation sources.

Energy storage technologies present an option for meeting changing flexibility needs while also providing other grid services throughout the year. The trade-off between energy storage and other options to meet system flexibility needs will depend on many factors, including the periods in which additional flexibility is needed and costs of various options as well as considerations around security of supply and reliability.

7. Increasing Curtailment of Variable Renewable Energy Review

As of June 2021, Bangladesh's grid-connected variable renewable energy (VRE) capacity is 151 MW, with 1 MW of wind and 150 MW of solar, including rooftop solar (SREDA 2021). With a national installed capacity of 20,494 MW, grid connected VRE accounts for less than 1% of installed capacity in the country. Therefore, curtailment of VRE is not a major issue in the current system.

However, the country could begin to experience grid integration challenges associated with higher contributions of VRE. At the June 2021 Bangladesh-UK Climate Partnership Roundtable, the minister of MPEMR announced a goal that 40% of electricity will come from renewable sources by 2041 (Dhaka Tribune 2021b). As the contribution of VRE in the grid increases, energy storage can help integrate variable generation resources.

In fact, some in Bangladesh are already thinking through how storage could play this role. The National Solar Energy Action Plan recommends that once VRE is at 10% of installed capacity, each new VRE plant should be equipped with a storage system. The Plan anticipates this will occur between 2025 and 2030 (Chowdhury 2020). Therefore, whether through policy mandates or economic investments, there will likely be an emerging opportunity for energy storage to manage the variability of renewables such as wind and solar and reduce curtailment, maximizing the use of these resources and helping the country meet its renewable energy targets.

3.4 Policy

Bangladesh's energy policy does not establish a clear vision for energy storage in the country. Public support for specific projects has been inconsistent and the country lacks a clear policy framework that lays out the many services that storage can provide as well as the full range of storage technologies available.

8. Inclusion of Energy Storage in Energy Policy and Master Plan Revise

Bangladesh's energy sector policy and planning documents do not lay out a vision for the energy sector to contribute to the country's sustainable economic growth and development. The National Energy Policy 2005 and Electricity Act 2018 are the primary policy documents guiding the development of the electricity sector (MPEMR 2005; 2018a). Under the Electricity Act, energy storage would have to qualify as a generation, transmission, or distribution asset to be licensed for operation. The policy is silent as to whether energy storage, particularly non-PSH technologies, could qualify under one of these categories.

The PSMP 2016 and subsequent 2018 revision ("Revisiting PSMP 2016") present the country's planned energy and power sector development strategy through 2041 (MPEMR 2016; 2018b). The PSMP presents a favorable outlook for PSH technologies in Bangladesh, noting that PSH will play a critical role in meeting the country's renewable energy goals and transitioning away from the use of petroleum in power generation. It also includes a goal to commission the first such facility in Bangladesh, a 100-MW pumped storage addition to the Kaptai hydropower plant, by 2030. However, the 2018 revision does not mention PSH at all, and the planned 100-MW capacity addition at Kaptai is referred to as an "extension" rather than a PSH facility. Neither document outlines a role for non-PSH storage technologies outside of off-grid applications, such as part of solar home systems. The PSMP concludes that "[B]ecause battery and related technologies are still uncertain at this moment, they are not factored into the capacity projection."

The more recent National Solar Energy Action Plan, 2021–2041 does include a role for utility-scale storage to provide greater system flexibility and reliability (Chowdhury 2020). This plan, while not an official policy document, aims to inform decisions around new solar energy targets and strategies to achieve these targets. The plan notes that the value from peak shaving and providing spinning reserves will justify investments in large-scale storage installations.

Overall, Bangladesh's energy policy does not include a clear vision for energy storage in the country. It is unclear what, if any, role energy storage can play in the power sector under the current Electricity Act. The latest version of the PSMP excludes the endorsement and plans for PSH that were included in the previous version and does not mention other types of storage at all. Including clear policy guidelines on energy storage can provide a market signal to spur development and direct regulatory authorities to begin implementing targeted regulations. These should address the many services storage can provide as well as the full range of technologies available.

9. Targets for Storage Deployment

Review

The 2016 PSMP includes planned targets for expanding the electricity supply through 2041 through both domestic and imported resources. However, the revised 2018 plan does not establish targets for energy storage technologies, including PSH.

For policy makers in Bangladesh interested in promoting energy storage, there are alternative policy options that could be pursued in parallel to the country's goals for its generation mix. The National Solar Energy Action Plan includes recommendations to align storage deployment with the country's renewable energy targets. For example, the plan recommends all new renewable energy plants should include energy storage after the country reaches 10% installed capacity from wind and solar technologies (expected to occur between 2025 and 2030). By way of comparison, in India, Minister of Power R.K. Singh has proposed introducing a renewable purchase obligation for round-the-clock power as a mechanism to promote energy storage (ET Energy World 2020). Under the proposed scheme, increased demand for energy storage would drive investments in storage manufacturing facilities, driving down storage costs and accelerating the transition to renewable energy. Targets can be set in terms of either megawatts of installed capacity or megawatt-hours of utilization and may increase over time (e.g., storage target is 1% of generating capacity by 2030 and 3% by 2035).

Efforts to assess the economic feasibility of energy storage, such as the 2016 PSMP's identification of candidate PSH sites, can inform future policy targets. NREL is currently combining our flagship capacity expansion model, the Regional Energy Deployment System, or ReEDS, with a detailed production cost model of the South Asian power system to better understand the techno-economic potential for energy storage in the region. The results can help inform where and when utility-scale energy storage is cost-effective and the drivers for energy storage investments.[9]

10. Energy Strategy Promotes Operational Flexibility

Revise

Enhancing the flexible operation of the power system is the first of "five key viewpoints" included in the 2016 PSMP to achieve the GOB's Vision 2041 goals. Despite this prominent position, the development strategy outlined in the 2016 PSMP and the 2018 revision gives very little attention to achieving greater operational flexibility.

In the current system, gas- and oil-based thermal plants are the primary sources of flexibility for load following and peak demand management (MPEMR 2016). As the contribution of renewable energy increases, demand grows, and the country pursues a phaseout of oil-based plants, the need for flexible resources is likely to increase. The PSMPs do not include an assessment of current or future needs and resources for system flexibility. The only sources of new operational flexibility mentioned are hydropower plants and demand-side management. In the case of hydropower, operational flexibility is included as 1 of 10 criteria in the evaluation of candidate hydropower sites but it is given a minimum weighting of only 1 (out of 30 total) (MPEMR 2016).

With response times that are comparable to or faster than conventional generation technologies, energy storage technologies can improve system flexibility and reliability. Incentivizing investments in flexible resources to realize these benefits will require greater attention in power sector policy to promote increased operational flexibility and regulations for fast-responding assets. Furthermore, including a range of storage technologies that are eligible to meet flexibility needs can increase the total amount of fast-responding assets available for balancing.

11. Support Organized Knowledge Sharing and Delivery for Scale-Up and Replication

Review

[9] For more information, see https://www.nrel.gov/international/energy-storage-south-asia.html.

There are currently no initiatives or organizations focused on promoting energy storage in Bangladesh. One useful model could be the Bangladesh Independent Power Producers' Association (BIPPA) (BIPPA 2018). This organization serves as a single point between government and the private sector to coordinate planning and support the implementation of the PSMP. While the majority of BIPPA's 52 members are involved in diesel, fuel oil, and gas projects,[10] the association is not limited to these technologies. If the GOB signals renewed support for energy storage projects through inclusion in national policies or the PSMP, the BIPPA could be used to support capacity building and project development among energy storage professionals.

An alternative to privately led organizations such as the BIPPA could be a new government agency focused on energy storage. In the United States, the State of New York is using its state agency, the New York State Energy Research and Development Authority (NYSERDA), to promote the energy storage market. NYSERDA is responsible for allocating state funds to implement storage incentive programs and serves as the clearinghouse for information on incentives and technical resources for installing and operating energy storage facilities, opportunities for researchers and manufacturers to develop new energy storage technologies, and the state's progress toward its clean energy goals. NYSERDA also connects technical experts to developers and contractors via one-on-one consultations to help with project siting, sizing, and economics (NYSERDA 2020).

While these types of government or private organizations are not necessary for energy storage deployment, they can play an important role in raising the profile of energy storage opportunities and accelerating the adoption of appropriate storage solutions. This is particularly important in Bangladesh, where there are no utility-scale energy storage projects to date and experience among policy makers, regulators, developers, and the public alike is limited.

12. Domestic Industrial Policy Supports Storage Manufacturing

Review

The Bangladesh Industrial Policy 2005 does not include any specific support to the energy sector. Promoting the entire supply chain for energy storage technologies, including local manufacturing and assembly for storage components and trained technicians and staff for after-sales service, is a key step in developing an enabling ecosystem for storage deployment. For example, in Nepal, "energy-oriented industries" are included in a list of 10 prioritized sectors eligible for various tax incentives (Government of Nepal 2011). In India, the government is seeking to set up large-scale battery giga-factories through its National Mission on Transformative Mobility and Battery Storage (GOI 2019). This policy is targeted to electric vehicle applications but could be expanded or replicated to include power sector applications as well.

13. Targeted Support to Early Adopters

Review

[10] The only exception to this group is Technaf Solartech Energy Limited, developer of a 20-MW solar plant.

New technologies often face a funding gap between research and development and full commercial deployment. This is particularly true for technologies—such as energy storage—that can provide a range of system benefits, some of which are not monetized through existing markets or tariffs. Public support programs can help overcome this gap and accelerate the deployment of energy storage technologies.

While Bangladesh does not have specific programs or policies to support energy storage deployment, the policies developed to promote private sector investments illustrate how such programs could be implemented in the future. For example, the Private Sector Power Generation Policy of Bangladesh, 1996 (later revised in 2004) established a number of mechanisms to incentivize private investments, including tax exemptions, easier access to credit from banks, and attractive profit margins (MPEMR 2004). Another key instrument established by the policy was the Power Cell, a GOB agent responsible for facilitating all stages of promotion, development, implementation, commissioning, and operations of private power generation projects. By serving as a single nodal agency between the GOB and private developers, the Power Cell is intended to streamline the process of establishing a new generation facility in the country for prospective developers.

An alternative method of public support is indirect support to highly impactful projects. In Nepal, the government is promoting the development of PSH by undertaking feasibility studies for specific projects and directing the national utility to develop a PSH pilot (Kathmandu Post 2014; MOEWRI 2018). This pilot project will be the country's first utility-scale storage project, and the utility will recover the project costs through its regulated tariff. This support strategy has several key benefits. First, by undertaking the feasibility studies, the government reduces the risks and costs for project developers to identify economically and technically feasible projects. Second, it reduces the risk for lending institutions to finance the project because the utility has a cost recovery mechanism in place. Finally, it enables the country to gain valuable experience developing and operating a PSH plant to learn more about the economic potential for utility-scale storage technologies in the power system.

Targeted government support can help bridge the funding gap, reduce risk, and help new storage technologies reach commercial maturity. Support programs that are technology agnostic, focused on desired capabilities rather than specific technologies, can encourage a wider range of possible storage solutions.

3.5 Regulation

Existing regulations restrict energy storage—particularly nonhydro storage—from providing services or earning revenue for those services. These rules present a barrier to identifying and maximizing the cost-effective value of storage investments.

14. Utilities and Private Developers Allowed To Make Storage Investments	Revise

Rules defining activities that require licenses are included in the Bangladesh Energy Regulatory Commission Act, 2003 (BERC Act, 2003) (BERC 2003). Under these rules, a license is required and may be issued to any person for the purpose of energy storage. However, the BERC Licensing Regulations 2006 do not include rules for licensing of energy storage technologies, with the exception of PSH (BERC 2006). Expanding the licensing regulations to allow investments in *all* energy storage technologies from *any* type of developer can increase the investment potential of energy storage technologies in the country.

15. Interconnection Processes Give Storage the Right To Interconnect and Obtain Transmission Service	Review

The BERC Electricity Grid Code 2019 (Grid Code) includes detailed Connection Conditions that outline the technical and operational criteria as well as the application process for users seeking to connect to the transmission system (BERC 2019). The Connection Code is divided by user type, including generation, distribution, large consumers, and "other users." Under the definitions outlined in the Grid Code, PSH and storage connected to a solar PV facility qualify for connections as generators. The Connection Code does not address other stand-alone storage technologies, but they may be able to interconnect as part of the latter group of "other users." The Connection Conditions require any user seeking to connect to the transmission system to obtain an agreement, generally in the form of a PPA or power sales agreement, with BPDB, the single buyer for all generators in the country. For closed-loop storage facilities (e.g., stand-alone battery facility), it is not clear what such as agreement with BPDB would look like.

The Grid Code could be expanded to explicitly include a wider range of possible storage solutions, including mechanical, electrochemical, and thermal storage technologies in its Connection Conditions. Additional steps could further expedite interconnection approvals for storage projects. For example, the grid operator could publish a network map of preferred storage locations or allow expedited approval for projects with low anticipated negative impacts on the grid, to incentivize storage investments in areas that support the grid.

16. Promotion of High-Quality Standardized Storage Technologies Through Safety Standards	Review

BERC is responsible for setting safety standards for the electricity sector (BERC 2003). In its Grid Code, there are no safety standards or procedures in place for energy storage technologies in Bangladesh. BERC has established a process for assessing the performance of generating units through regular audits (BERC 2017). The plant performance is reported using six key performance indicators (KPIs): heat rate, availability factor, equivalent forced outage rate, auxiliary consumption, available capacity, and greenhouse gas emissions. There are no minimum KPI requirements for generation plants, but BERC will make recommendations to improve plant performance and efficiency in cases where the results fall below industry standards.

This audit process could serve as a useful model for implementing and enforcing safety standards for energy storage technologies. Because storage is a relatively new technology, some capacity building may be required to inform the development of appropriate safety standards for energy storage systems. For example, in India, the Indian Energy Storage Alliance is collaborating with UL and the Bureau of Indian Standards to identify gaps in existing standards and develop new rules to safely integrate energy storage systems into the Indian grid. If interest in energy storage technologies in Bangladesh grows, increased education, training, and technical support for the development of new codes, standards, and regulations will be critical for the safe and timely deployment of these technologies.

17. Operating Requirements for Fast-Responding Assets

Revise

The Grid Code 2019 stipulates ancillary service requirements for generators to enable the system to better respond to unexpected deviations. These include requirements for frequency regulation, voltage regulation, operating reserves, and black start capabilities (BERC 2019). Rather than specify a quantum of reserve requirements, the grid code sets requirements for all generators as part of their connection agreement. For example, all generating units are required to provide primary voltage control through AVR. Generators are required to provide these services but are not explicitly compensated for doing so.

In practice, the actual supply of fast-responding assets has been insufficient, resulting in frequency and voltage deviations outside of BERC's targets of 50 ±0.5 Hz for frequency and ±5% for 400 kV lines and ±6% for 230 kV and 132 kV lines for voltage (MPEMR 2016). In some cases, the design of the regulation itself does not ensure system reliability. For example, system voltage is poorly maintained in the Western and Northern regions due to long transmission lines and a lack of generating plants in those regions. Therefore, even if all units are providing AVR as required, these regions may still experience voltage fluctuations.

Despite regulatory efforts to promote fast-responding ancillary services, two key barriers remain to achieve the desired amount of system flexibility. First, BERC has yet to mandate the quantum of reserves required for each service. As the country's electricity demand and generation mix continue to change, the amount of fast-responding assets required to maintain system reliability will also change. A detailed assessment of reserve requirements can inform what, if any, changes are required in the Grid Code to ensure the existing and planned systems have adequate fast-responding assets. Second, current regulations exclude certain technologies from providing ancillary services. For example, nonhydro energy storage does not qualify as a conventional generator to provide frequency regulation. Updating current regulations to signal the desired amount of ancillary services required to maintain reliable power supplies can signal investment needs among project developers. And expanding the range of technologies eligible to provide these services to include energy storage technologies can increase the amount of fast-responding assets available to meet those needs.

18. Electricity Service Charges Reflect the Value of and Increase Price Transparency for Energy Services

Review

Guidance on electricity charges in Bangladesh has long emphasized the need to reflect the cost of electricity supply and promote the efficient use of resources (Government of Bangladesh 2020). Historically, revenue from electricity tariffs have not covered the cost of supply, resulting in a net loss for BPDB (BPDB 2020). Recent tariff updates by BERC have included peak and off-peak pricing for consumers connected to medium, high, and extra high voltages, to encourage load shifting away from peak demand hours. This includes industrial and commercial sectors, which accounted for 39% of electricity consumed in 2019-2020 (BPDB 2020).

On the supply side, it is not clear whether electricity rates—either through regulated tariffs or PPAs—include price signals to encourage investments in technologies that best fit the needs of the system. In India, for example, recent tariff updates by the Central Electricity Regulatory Commission are improving price signals from regulated tariffs to improve generator availability during peak demand periods. The tariff generators receive comprises a variable- and a fixed-cost component. For PSH and thermal plants, the fixed-cost component includes a capacity charge based on generator availability during high demand periods. PSH plants are required to pump water to an upper reservoir during off-peak hours and maximize available supplies during peak hours to receive a capacity payment each day. For thermal plants, capacity payments are higher for peak hours and high demand months. Both approaches encourage generating units to be available when most needed (i.e., during high demand periods). To further incentivize greater reliability, thermal generators can earn an additional payment of INR 0.65 (0.76 BDT) per kWh for energy scheduled during peak hours and INR 0.50 (0.58 BDT) per kWh for energy scheduled during off-peak hours in excess of the normative plant load factor (CERC 2019).

A similar approach could be used in Bangladesh, and expanding the pricing mechanisms to be technology-agnostic could encourage greater availability and performance of the entire generation fleet. In addition, tariff reforms for ancillary services could also improve system performance. Under the Bangladesh Electricity Grid Code, generators are required to provide frequency regulation and other ancillary services but are not compensated for doing so. Including a payment for ancillary services that values the speed and accuracy with which these resources can respond can incentivize investments in fast-ramping resources, such as energy storage, and improve system reliability while also lowering the country's total ancillary service requirements.

19. Storage Able To Compete with Other Grid Assets To Provide Multiple Services

Revise

While the BERC Act 2003 allows for investments and licensing of any type of energy storage facility, the Grid Code is more restrictive (BERC 2019). PSH is the only stand-alone storage technology that meets the definition of a generating unit. As such, it is eligible to provide energy and ancillary services to improve power quality. Nonhydro storage technologies are only eligible to provide grid services as part of a PV Generating Plant that can be developed "with or without storage unit." These services are limited to energy and reducing variability of power output from the connected renewable energy plant. In both cases, energy provision is the only service that is explicitly compensated.

Energy storage is technically capable of providing a range of grid services, but existing regulations restrict the use of nonhydro technologies. Expanding the range of technologies eligible to provide grid services could enable the identification of cost-effective technologies best suited to meet system needs.

20. Storage Able To Receive Revenue for Providing Multiple Services	Revise

Being eligible to provide grid services is one aspect of establishing a fair playing field for energy storage. The other critical consideration is whether energy storage can be compensated for the value it provides to the grid. While the BERC has not established a rate structure for energy storage projects, the existing rate structure for utility- and IPP-owned projects provide some insight into the types of compensation storage projects may receive.

Utility-owned projects are remunerated under cost-of-service regulation overseen by the BERC. Therefore, there is no direct compensation for specific projects or specific services; the utility must use its own internal analysis to identify the appropriate mix of technologies to meet its needs. IPP plants are compensated for energy only through their PPA agreements with BPDB. Including an incentive for projects to provide diurnal load shifting and peak demand management as part of the rate structure in these agreements could encourage storage projects that meet system needs.

In other cases, such as ancillary services, generators are required but not paid to provide these services. This has implications for the economic viability of nonhydro energy storage projects as revenue from energy sales alone may not be sufficient to cover the costs of a stand-alone energy storage facility. It may also impact the performance of grid assets providing ancillary services because there is no investment incentive for technologies with superior speed and accuracy to meet ancillary service needs. Energy storage, with its ability to rapidly respond to control signals to inject or withdraw power, could improve system operations.

Revising existing compensation mechanisms to reflect the desired needs and capabilities of the system for a broader range of energy services, including energy, load following, peak management, and ancillary services, could improve the economic viability of suitable technologies, including energy storage, and improve overall grid performance.

4 Guidelines for Policy Makers and Regulators

The application of the Energy Storage Readiness Assessment for Bangladesh reveals technical and economic opportunities for energy storage to provide ancillary services and peak demand management. However, within the country's policy and regulatory frameworks there are significant barriers to enabling storage projects to provide these services.

Bangladesh's existing energy policy does not lay out a clear vision for energy storage in the country. Some activities, such as the National Solar Energy Action Plan and NREL's analysis on techno-economic opportunities for energy storage in Bangladesh, can inform the development of a policy framework for energy storage that addresses the many services that storage can provide as well as the full range of storage technologies available. Having this framework in place can accelerate the identification and implementation of system-appropriate storage solutions.

Bangladesh, like most countries, is in a familiarization stage with nonhydro energy storage technologies. Establishing a forum for knowledge exchange where stakeholders can find resources and share best practices can help with scale-up and replication of successful projects.

Integrating energy storage into national energy policies also enables regulatory authorities to begin implementing necessary regulations to achieve these policy outcomes. Chief among these in Bangladesh are regulations that enable energy storage to obtain a license to provide a wider range of grid services and accompanying compensation mechanisms—whether through regulated tariffs or markets—to earn revenue for those services.

The range of energy storage technologies for utility-scale grid applications is expanding quickly, including multiple forms of mechanical, electrochemical, and thermal energy storage. Policy makers and regulators can encourage technology innovation through technology-agnostic policies, programs, and rules focused on desirable characteristics and operating requirements rather than specific technologies. A technology-agnostic approach will avoid creating artificial barriers for emerging technologies.

As the Bangladesh power system continues to transform, energy storage technologies can contribute to meeting evolving system needs for flexibility and reliability. Comprehensive policy and regulatory frameworks can enable economically viable storage technologies to meet these needs.

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