The Malawi Priorities Project

Cost-Benefit Analysis of Power Sector Reform for Business Friendliness in Malawi - Technical Report

National Planning Commission Report with technical assistance from the Copenhagen Consensus Center and the African Institute for Development Policy

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AFIDEP
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This work has been produced as a part of the Malawi Priorities project.

Malawi Priorities: Background

Malawi Priorities is a research-based collaborative project implemented by the National Planning Commission (NPC) with technical assistance from the African Institute for Development Policy (AFIDEP), and the Copenhagen Consensus Center (CCC) to identify and promote the most effective interventions that address Malawi's development challenges and support the attainment of its development aspirations. The project seeks to provide the government with a systematic process to help prioritize the most effective policy solutions so as to maximize social, environmental and economic benefits on every kwacha invested. Cost-benefit analysis is the primary analytical tool adopted by the project. Cost-benefit analysis will be applied to 20-30 research questions of national importance. Research will take place over the course of 2020 and 2021.

Research questions were drawn from the NPC's existing research agenda, developed in September 2019 after extensive consultation with academics, think tanks, the private sector and government. This sub-set was then augmented, based on input from NPC, an Academic Advisory Group (AAG) of leading scholars within Malawi, and existing literature, particularly previous cost-benefit analyses conducted by the Copenhagen Consensus Center. The research agenda was validated and prioritized by a Reference Group of 25 prominent, senior stakeholders. The selection of interventions was informed by numerous consultations across the Malawian policy space, and one academic and two sector experts provide peer review on all analyses.

Cost-benefit analyses in Malawi Priorities consider the social, economic and environmental impacts that accrue to all of Malawian society. This represents a wider scope than financial cost-benefit analysis, which considers only the flow of money, or private cost-benefit analysis, which considers the perspective of only one party. All benefit-cost ratios (BCRs) reported within the Malawi Priorities project are comparable.

The cost-benefit analysis considered in the project is premised on an injection of new money available to decision makers, that can be spent on expanding existing programs (e.g. new beneficiaries, additional program features) or implementing new programs. Results should not be interpreted as reflections on past efforts or the benefits of reallocating existing funds.

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Contents

Acronyms

ATC&C	Aggregate technical, commercial and collection losses
CBA	Cost-Benefit Analysis
CCC	Copenhagen Consensus Center
DISTCO	Distribution and Transmission Company
IHS	Integrated Household Survey
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt Hour
GWh	Gigawatt hour
MCC	Millennium Challenge Corporation
MDB	Multilateral development banks
MW	Megawatt
MWh	Megawatt Hour
NPC	National Planning Commission
OGS	Off-grid Solar
PPP	Public-Private Partnership
QFD	Quasi-fiscal Deficit
SHS	Solar Home Systems
T&D	Transmission and Distribution
TA	Technical Assistance
USAID	United States Agency for International Development
USD	United States Dollar

1. Summary

How can the provision of utilities be made more reliable to enhance Malawi's business friendliness? This paper details the cost-benefit analysis of a project that would strengthen the regulation and operational management of the power sector in Malawi, which is crucial to ensuring the sustainability of previous reforms. Operational weaknesses can prevent power from reaching customers even when it is available. Specifically, we recommend the ESCOM board consider a long-term technical assistance program to improve corporate governance and management practices. We suggest a multi-year program to align with Malawi's aspiration to middle-income status by 2030, with the option to revisit the arrangement in 2025. Based on international evidence, the program is expected to reduce transmission losses, keep transmission outages in check and improve reliability of service provision. The benefits of this analysis are avoided technical losses which eventually flow through to businesses and households as higher net income. These are substantial – by 2030 we estimate benefits at MWK 110 billion, or 1% of projected GDP, a significant contribution to Malawi's goals of achieving 6% GDP growth annually. The costs include an intervention design phase and ten years of technical assistance for ESCOM and the Malawi Energy Regulatory Authority (MERA) to make the recommended changes. The benefit-cost ratio is 41 at an 8% discount rate.

2. Introduction and Context

Access to reliable electricity has critical impacts on household welfare, business productivity and growth. In Malawi, the power sector has undergone many changes in recent years, with notable improvements. However, barriers remain to reliable electricity provision.

Access to electricity is severely limited in Malawi. According to the 5th Integrated Household Survey, 11.2% have access to the electrical grid, with rural electrification rates about ten times lower. There have been large efforts to expand transmission and distribution, connect more customers to the grid, and improve service delivery. Despite these investments over the past years, there is room for improvement: Malawi has an installed capacity of 482 MW with demand of 440 MW (World Bank, 2019).[1] Still, the service is plagued by blackouts, mainly due to Malawi's heavy reliance on hydro-power and declining water levels in the Shire River. Ramachandran et al. (2018) estimate that Malawian firms experience approximately 7.4 outages per month, with each outage lasting 3.6 hours. Around half of firms cope with these losses by adopting expensive diesel generation. The other half opts into low productivity enterprises or experiences significant loss in sales. The average monthly loss of sales due to blackouts in Malawi is estimated at 7.6% (Ramachandran et al. 2018). Furthermore, according to the 2018 Doing Business Report, procedures, time, cost to get connected to the electrical grid, the reliability of electricity supply, and the transparency of tariffs in Malawi are ranked extremely low (169th out of 190 countries) and below the Sub-Saharan African average (World Bank 2019).

There are several stakeholders in the local energy architecture. The Ministry of Natural Resources, Energy, and Mining (MoNREM) sets the energy sector's overall policy. The Malawi Energy Regulatory Authority, established in 2007, is an independent electricity regulator, whose many tasks include the review of tariff applications and recommendations for tariff changes from ESCOM. One significant reform in recent years was the unbundling of the Electricity Supply Corporation of Malawi Limited (ESCOM), Malawi's main electricity utility, in 2017. The newly created Electricity Generation Company Malawi Limited (EGENCO) is responsible for the generation of electricity and improvement of the Malawian government's power stations while ESCOM handles distribution and the dispatch transmission center. The newly created Power Market Ltd (PML) is expected to take over transmissions and dispatch management. PML was incorporated in 2018 and became operational in 2020 but has not yet taken over transmission and dispatch roles.

Malawi was under a Millennium Challenge Corporation Compact for five years (2013-2018). The improvements made during period were substantial. However, coverage and reliability remain lower than in comparable countries. For example, installed capacity in Malawi is 482 MW; in Zambia and Mozambique it is 2800MW and 2827 MW, respectively. Zambia is a comparable country, where it relates to population, with 17.9 million versus Malawi's 18.6 million. Further, Rwanda has far less capacity (218 MW), no doubt in part to its slightly smaller population of 12.6 million, but triple (30%) the coverage of Malawi (11%) (Power Africa, 2021).

An independent evaluation of the MCC Compact found that the financial position of ESCOM has declined in recent years. Sabet et al. (2019) found that there have been significant issues in ESCOM operations, and the board of directors of ESCOM may not be sufficiently independent from political authorities. Additionally, while tariffs have increased significantly, they are still below full cost recovery levels. However, we note that tariff setting has a political dimension that goes beyond ESCOM's direct control. As a result of these issues, the sustainability of the MCC supported improvements cannot be guaranteed.

Recently, in the State of the Nation Address, the President committed to increasing Malawi's generation capacity by 1000 MW by 2025. Such an expansive generation agenda makes it even more important that management of the sector is improved.

2.1 Research process

The National Planning Commission (NPC), with technical support from the African Institute for Development Policy (AFIDEP), and the Copenhagen Consensus Center (CCC) are undertaking cost-benefit analysis across a wide range of policy areas with the aim of assisting the Government of Malawi in its prioritization of spending across sectors.

The project, 'Malawi Priorities', and its research agenda takes its starting point in the NPC's existing research agenda, which is structured around the six thematic areas of Sustainable Agriculture, Sustainable Economic Development, Human Capital and Social Development, Sustainable Environment, Demography, Governance, Peace, and Security. The NPC's research agenda predates the Malawi Priorities project and underwent a separate validation process. Furthermore, a Reference Group of 24 experts from a variety of sectors were polled to identify the most pertinent research questions and potential interventions for study. The following research question is the result of these two processes:

How can the provision of utilities be made more reliable to enhance Malawi's business friendliness?

The authors and CCC chose electricity as the focus of this research. The team reached out to sector experts, including those familiar with the recent interventions in the Malawi power sector. These consultations were an opportunity for the team to learn about the context of Malawi's power sector, to identify key issues, and discuss possible solutions. A literature review to investigate the impact of the past and current interventions in Malawi, including the recent MCC Power Sector Reform Activity (2013-2018) and the World Bank Malawi Electricity Access Project to expand coverage that began in 2019.

[1] Here 'demand' reflects the consumption of electricity of those connected to energy generating sources such as the grid. It excludes those who would like to consume electricity but lack a connection to the grid.

3. Intervention selection, literature review

Before the MCC Compact Power Sector Reform activity, ESCOM suffered from operational and governance challenges related to insufficient management capacity, unresponsive customer service, weak internal controls, political interference, and poor transparency (Sabet et al. 2019). The five year technical assistance of the MCC included a component to improve and sustain better management practices within ESCOM; for example mentoring and on-site advisors, regular and ad hoc meetings to press for action on specific issues, and follow up monitoring activities to assess progress. Despite this, the independent evaluators highlight corporate governance as well as operations and management as the weaker outcomes of the 5 year project. Transmission outages, the principal cause of the unreliability of service, are essentially the result of this sub-optimal management. Sabet et al (2019) include stock-outs, procurement maintenance calendars not being maintained, and lack of knowledge of adaptation strategies to mitigate climatic changes as examples of management issues leading to technical losses. Operational weaknesses can prevent power from reaching customers even when it is available (Foster and Rana, 2019).

The financial position of ESCOM has also been another challenge to Malawi's power sector. The tariff in Malawi has not been cost-reflective (partly due to political factors beyond ESCOM's control), which has left ESCOM unable to cover its cash flow requirements. Due to this poor financial situation, the Government of Malawi has had to cover the debts of ESCOM. This has impeded ESCOM's ability to perform regular operation and maintenance and has led to focusing new connections on high-value customers (World Bank, 2019). The MCC Power Sector Reform Activity financial analysis recommended a sustainable debt management plan, a plan for reducing ESCOM's operation costs, and a new tariff adjustment methodology, among other interventions, in order to improve ESCOM's financial health (Sabet et al. 2019). While many of the practices recommended by MCC were adopted initially, there was evidence that they were not being used at end line and there remains concerns of the tariff not being cost-reflective (Sabet et al. 2019). Hence there is a need for a long-term technical assistance/mentoring program to improve corporate governance and management practices; in turn keeping technical losses to a minimum.

It is common for interventions to fail or be unsustainable in the electricity sector, particularly when the transmission and distribution company's reforms have not included significant corporate governance or management improvements. Management contracts, when well designed, can lead to significant improvements in utility performance. Sullivan and Eisendrath (2007) identify ten management contracts in the water and power sector that have generally resulted in large improvements in utility performance. By analyzing operating contracts that have been implemented in various countries, they find that these contracts can be very effective. However, the contracts must be tailored to the context, and mistakes in project design can be costly. Wood (2018) concludes that well-designed management contracts such as the ones in the Republic of Georgia and Kenya have resulted in significant performance improvements. This analysis found that through the duration of contracts, the operator is able to improve systems and procedures, introduce new equipment or workflows, and train the management team that will take over operations at the end of the contract. Our proposed intervention is based on the important lessons learned that are summarized in the Wood (2018) report.

Improving service reliability, through technical assistance programs, can also assist in setting cost-reflective tariffs, which further improve the ability to provide reliable services, generating a virtuous cycle. As noted in Kojima and Trimble (2016) "utilities need to focus on achieving an acceptable level of service quality to launch a trajectory toward cost recovery in tariff revenues", with the recommendation of small, frequent increases rather than large one-off increases. The example of Guatemala provides a good case study of management and institutional reforms that led to cost-recovery and service improvement (Alvarado and Belt, 2018 – see case study box).

Bacon (2018) reviews the impacts of four components of sector reform, including unbundling, technical assistance, regulation, and competition on performance indicators. The author concludes that technical assistance has the strongest potential effect to increase labour productivity and to reduce AT&C losses.

Among the pre-existing conditions identified by Bacon (2018) that motivated reform were:

- Poor performance in terms of high cost, unreliable supply, inadequate expansion of access, and low quality of service
- The inability to finance the needed expenditure on maintenance and expansion
- The burden on the government of holding tariffs below costs to avoid unpopular price increases
- The use of costly generation technologies

Many of these issues are present in Malawi and suggest that there would be great benefits from improved corporate governance. The literature review analyzing the impact of unbundling, technical assistance, and improved regulation showed that assistance

[1] James Sullivan and Allen Eisendrath, Operating Contracts for Managing Infrastructure Enterprises under Difficult Conditions. Washington, DC USAID and Energy Markets Group; 2007.
[2] Randall Wood, Best Practices for Performance-Based Management Contracts for The Power Sector USAID 2018
[3] Bacon, Robert. (2018) "Taking Stock of the Impact of Power Utility Reform in Developing Countries". Policy Research Working Paper 8460. World Bank Group.

led to significant decreases in technical and distribution losses. While Malawi has unbundled the various parts of the electricity supply chain, the literature suggests that such mentoring and improved regulation could help address its current challenges.

The World Bank (2009) found that an improved regulatory framework led to increased coverage, improved customer service, and reduced technical losses, which were sustained years after the project in many countries in Central and Southern America. They also highlight the importance of cost-reflective tariffs, specifically in the face of a financially weak single buyer.

3.1 Intervention

The intervention proposed is to ensure the sustainability of the previous reforms in Malawi by addressing the quality of operational management within ESCOM. Materially, the principal activity is ten years of technical assistance. Additionally, it is proposed that in the initial year there is an intervention design phase, potentially including a Political Economy Assessment (PEA) to ensure that the proposed interventions are fit-for-purpose and receive support from key stakeholders. While the MCC Compact demonstrates that technical losses can be reduced from improved management and infrastructure, a design phase is required in part to determine why these could not be sustained and inform intervention design.

Improved management practices will directly address the problem of unreliable service provision, as evidenced by frequent transmission outages, which can be directly attributed to declining water levels in the Shire River. Ganon et al. (2018) discuss the impacts felt by small and medium enterprises in the context of hydrological variability in Gaborone, Nairobi and Lusaka. They argue that poor planning, underinvestment and limited integration of hydrological models into decision-making often exacerbate the negative impacts of climate change. Improving the energy sector's adaptive capacity, including the use of geospatial data, is among some of the management competencies that will be needed to better manage electricity services in Malawi.

Case Studies of Successful Electricity Reforms in Kenya and Guatemala

Kenya

Wood (2018) notes the example of technical assistance support provided to the Kenyan operator, Kenya Power and Light Company (KPLC). From 2006 to 2008, KLPC was supported in operations, tariff setting and capital works by Manitoba Hydro International (MHI) a Canadian based firm. The program was structured such that MHI had management autonomy, including for operations, maintenance and disconnecting non-paying customers. However, MHI and KLCP had joint representation on a steering committee that set broad operational aims. Furthermore, MHI required approval for changes to tariffs, capital works and staffing. As a result of the assistance, technical and commercial losses fell 3%, 260,000 more households were connected to the grid and KLCP achieved savings of more than $25 million per year. MHI achieved most of its contractual targets. Wood (2018) reports that the partnership was deemed so successful that KLCP and MHI entered an MOU to support turnarounds in other countries.

Guatemala

Alvarado and Belt (2018) provide a description of a successful program that improved energy provision and enabled the setting of cost reflective tariffs in Guatemala, after it was exiting from an extremely violent 40-year civil war. Reforms were enacted in a General Electricity Law in 1996, and was implemented with the help of an international team of experts. One of the key features was allowing the energy distributor a fee - Value Added for Distribution (VAD) to cover distribution costs. This VAD is revised every five years, set by an independent body to reflect costs of an efficient firm. Independent Power Producers are selected using International Competitive Bidding (ICB), the Power Purchase Agreement (PPAs) are approved by the regulator, and the PPAs are readily available to the general public in the website of the regulator. The tariffs to the final users consist of the generation costs, the transmission costs, and the VAD. Importantly, tariffs are changed every three months mostly reflecting movement in the price of hydrocarbons including downward revisions when the prices of hydrocarbons decline.

From 1996 to 2018 this led to numerous achievements including almost $9 billion in private investment in generation, distribution and transmission, and generative capacity that is double peak demand. Electricity access is 92 percent, up front 63 percent in 1996. There is no load shedding in Guatemala. Importantly, Guatemalan households pay half the prices they did in 2010, showing that successful reforms can generate improvements and reduce costs. Guatemala exports excess energy to surrounding countries generating substantial foreign exchange reserves.

4. Cost-benefit analysis

The intervention is a long-term technical assistance program to support management short-comings leading to sub-optimal performance. The benefit of the technical support is the avoided technical losses that would otherwise have resulted in the absence of the intervention. The costs include an intervention design phase and ten years of mentoring for ESCOM and the Malawi Energy Regulatory Authority (MERA) to make the recommended changes.

4.1 Benefits

One of the outcomes of the MCC Compact was the reduction in total losses, which declined from 22% to 17% and can be almost entirely explained by the reduction in transmission losses, down to 5.7% from 10.5% (Sabet et al., 2019). Transmission losses lead to outages, which, in turn increase the coping costs of firms and households on the demand side.

This intervention's goal is to ensure that the improvements in technical losses as a result of the MCC compact are sustained, through improved corporate governance and administration. Without the intervention, we assume that technical losses will increase until they are 5 percentage points greater than their current level, to pre-MCC compact level.

Figure 1: Technical losses with and without the intervention

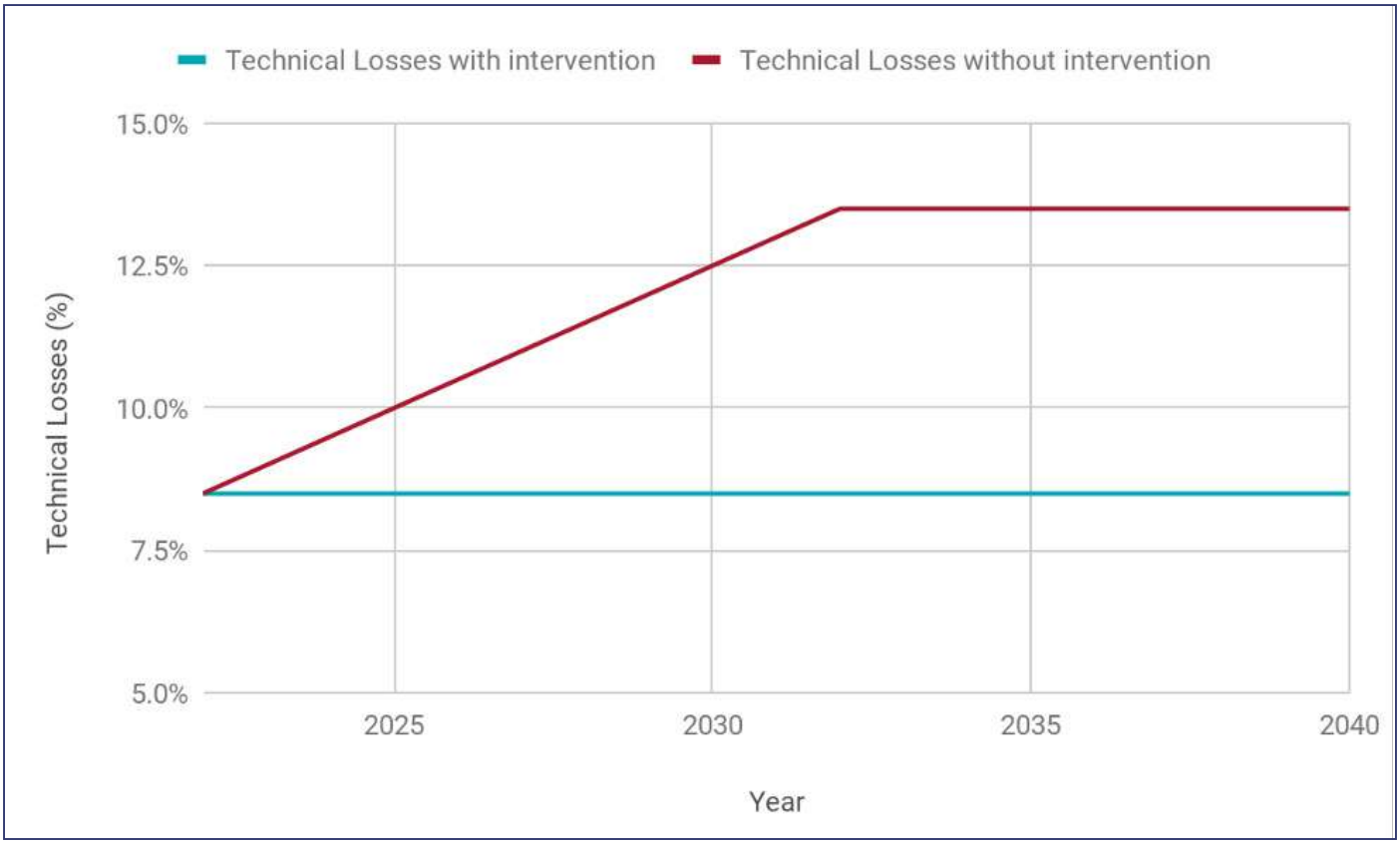


Figure 1: Technical losses with and without the intervention

Higher technical losses impact the reliability of electricity and power that could be consumed is lost. Given the current supply shortages and the targets for expanding coverage, we assume that all power saved through avoided technical losses can be used by consumers attached to the grid.

To evaluate the value of saved power, we use the coping costs of businesses and consumers in the face of blackouts to estimate the willingness to pay for the saved energy. Businesses' coping costs were estimated as the cost of self-generating power.

However, not all businesses in Malawi use generators in the face of power outages and smaller businesses often alter business hours in order to cope with them. Ramachandran et al. (2018) estimate that Malawian firms experience approximately 7.4 outages per month, with each outage lasting 3.6 hours. This causes firms to lose 7.6% of sales on average, though the experience across firms differ depending on the type of business. In particular, around 85% of Malawian firms fall into one of the following three main categories:

- *Plodders (40% of firms in the sample):* small to medium firms that do not own generators and do not lose much revenue (1.3%) due to blackouts.
- *Survivors (30% of firms in the sample):* large firms all of which own generators and also do not lose much revenue (3.1%) due to blackouts

- *Non-adopters (15% of firms in the sample):* small to medium firms 57% of which own generators and suffer very large revenue losses (31.05%) due to blackouts

Overall, 47% of Malawian firms in their sample use generators which is similar to Scott et al.'s (2014) estimate of 50% generator adoption rate for SMEs in developing countries. These statistics are for firms with at least 10 employees. For micro firms, Brailovskaya (2018) estimated that 1.79 work hours were lost per day among Malawian market vendors due to unreliable power.

The assumed coping cost of business is $2.09 per kWh, which has empirical and theoretical basis. First, it is the inflation adjusted price of diesel generation as estimated by Steinbuks and Foster, corroborated in another paper that estimated the levelized cost of energy of diesel grids in Malawi (Eales et al. 2020). Second, it appears from the above evidence that the primary long run coping strategy of SMEs that do not use generators is to opt-in to less productive and smaller enterprises that do not require electricity (plodders) or to a lesser extent endure losses in sales (non-adopters). In equilibrium, economic theory suggests this loss of productivity should equal the coping cost of $2.09 per kWh. If productivity loss were higher than coping costs then it would be beneficial to switch into an enterprise that requires electricity, and this would happen until the marginal firm's cost is also $2.09. The same logic holds for electricity-using firms with coping costs higher than estimated productivity loss.

For households, dry-cell batteries and torches (79.7%) and candles (3.9%) are the main coping strategies for households in the face of power outages, according to the 5th Integrated Household Survey (2019/2020). The cost of batteries and candles was used to estimate the coping cost for households.

Coping costs of businesses and households were then weighted by their respective share of consumed electricity. The share of electricity demand by households is 41.6% (Gamula et al. (2013). We also conducted sensitivity analysis on the coping costs between the cost of self-generating and the cost of power from the grid.

Table 1: Coping Costs of Electricity, Parameter assumptions

Parameter	Price per kWh (USD)	Share in total consumption
Cost to businesses of self-generating power	2.09	58.4%
Cost to households during outages	0.10	41.6%
Cost of power from the grid	0.16	N/A

To estimate the growth of power generation in Malawi, the team incorporated the increase in power generation estimated over the next four years by ESCOM. We considered three scenarios, shown below in Figure 2. The first scenario is the base case where the growth follows the historical trend of the past ten years. The second scenario is optimistic and assumes that the growth of power generation will increase to accommodate reliable power with 50% coverage by 2030, aligning with the target in the Malawi Vision 2063. The third scenario is pessimistic and assumes no growth after the first four years of the project. We conducted sensitivity analysis to look at the impact of the different scenarios on the Benefit-Cost Ratio (BCR). Figures 3 and 4 below show the technical losses with the base case and optimistic high growth scenario.

Figure 2: Power generation Scenarios

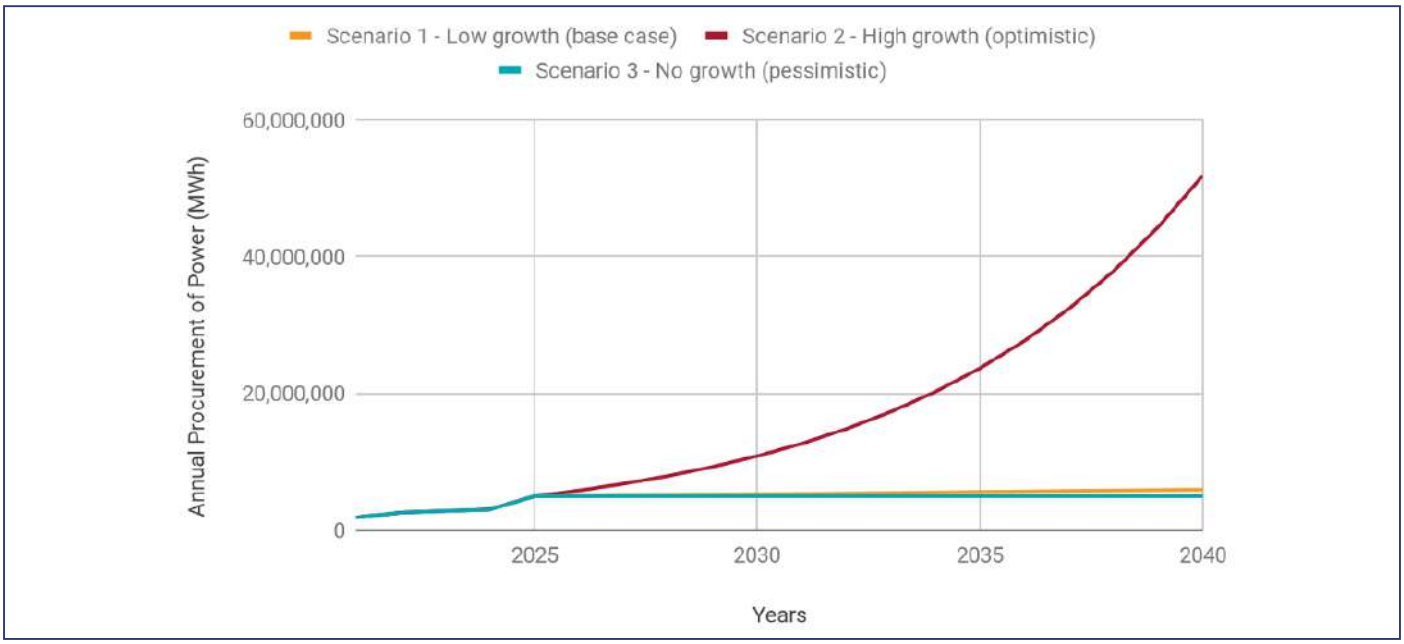


Figure 3: Technical Losses in the Base Case Scenario (low growth)

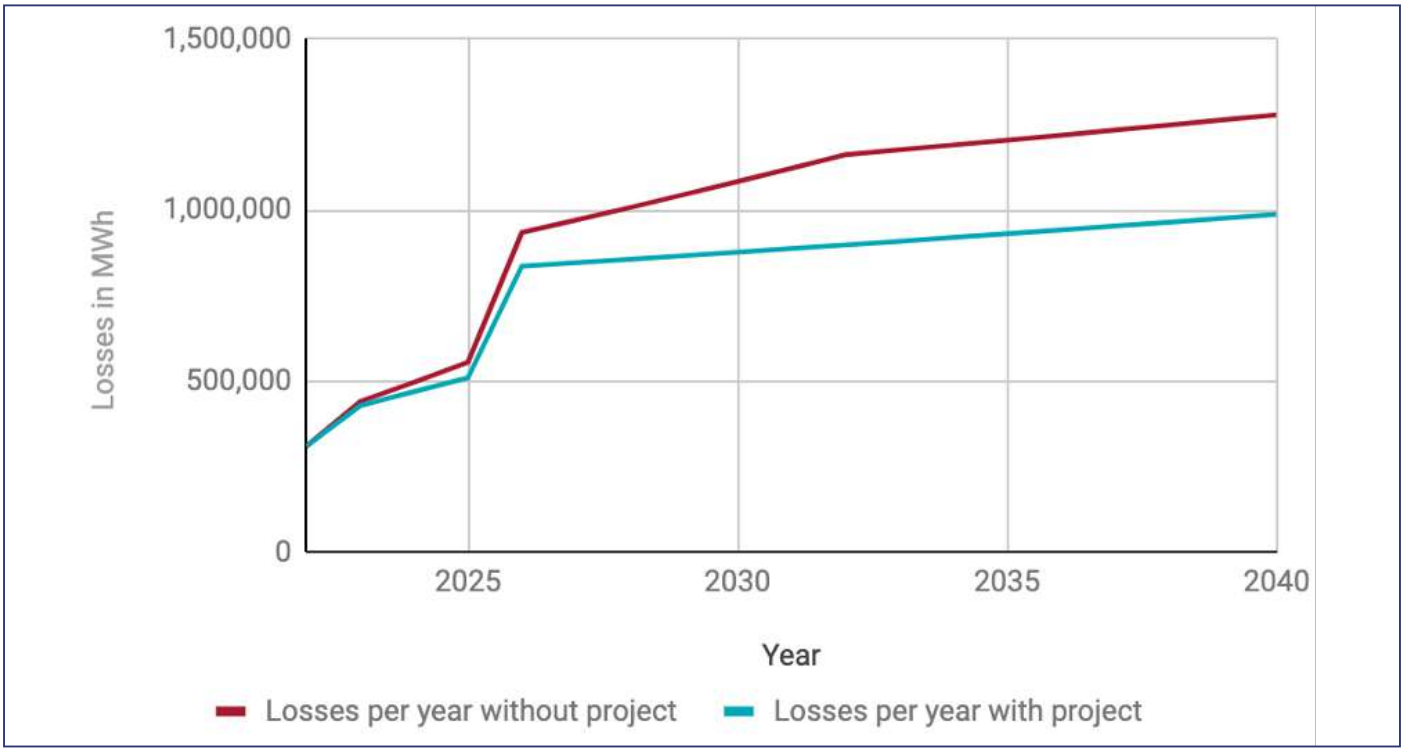
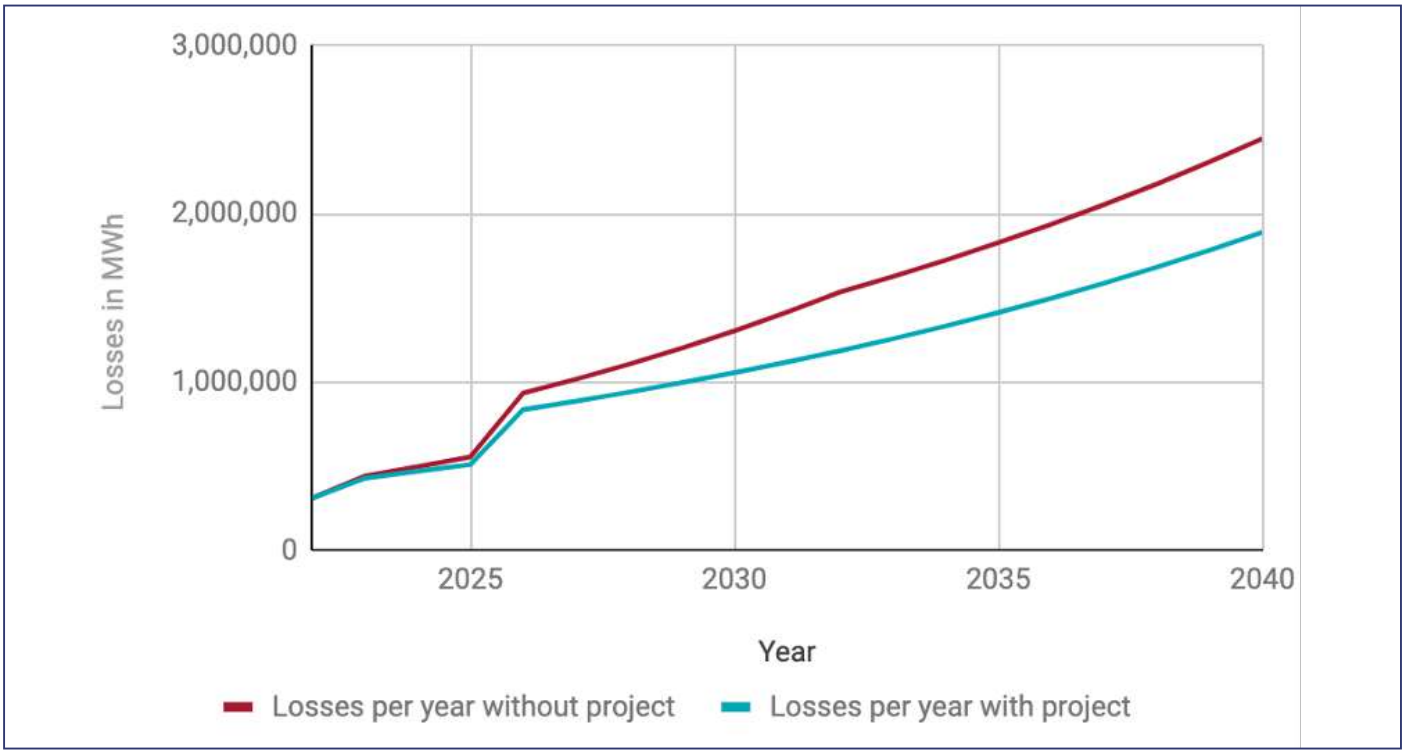


Figure 4: Technical Losses in Optimist Scenario (high growth)



4.2 Costs

The first year of the project will be used to conduct intervention design potentially including a Political Economy Assessment (PEA). The first year is estimated to cost USD 1 million. This phase would provide a more detailed project design that would refine the cost estimates.

Years 2 through 11 are for technical assistance with an estimated cost of USD 5 million per year, and these costs would be estimated more precisely after the first year. This intervention's cost was estimated using previous work in the power sector in other countries by USAID and other organizations in countries such as Guatemala and Nicaragua.

The intervention proposed would provide support for the power sector in Malawi for ten years. Because changes in the power sector happen over the medium-to-long term, we propose that the project will start with a four-year contract (one year for intervention design and three years for assistance), and will only continue the remaining years if certain improvements are made successfully. This support would arrest the highly probable increase in losses and mandate a pass through generation costs as described in Wood (2018). It will also include support for the ministry, the regulator, and stakeholders through a technical assistance program.

Evidence of successful technical assistance arrangements have been documented by Fisher et al. (2006) reviewing a water utility partnership in six African countries; Fall et al. (2009) reviewing turnarounds in urban water supply systems in Western African countries. Where it relates specifically to power sector reform, Foster and Rana (2019), in a review of research papers produced over the last 25 years, conclude that good corporate practices, particularly with respect to human resources and financial discipline, were associated with better utility performance, irrespective of whether the utility is publicly or privately managed. Furthermore, technical assistance programs in power transmission and distribution delivered good outcomes (efficiency and full cost recovery in Latin America and Asia, particularly in Colombia, Peru and Philippines).

4.3 Results

The analysis reveals that this project's benefits far outweigh the costs with a Benefit-Cost Ratio (BCR) of 41, at an 8% discount rate, and due to high uncertainty, moderately assuming that only 50% of the potential benefits are achieved. By directly addressing corporate governance and managerial inefficiencies, Malawi could save billions of Malawian Kwacha over the next twenty years. Table 3 below shows the net present value (NPV) of the benefits and costs of this project, as well as the benefit-cost ratio (BCR).

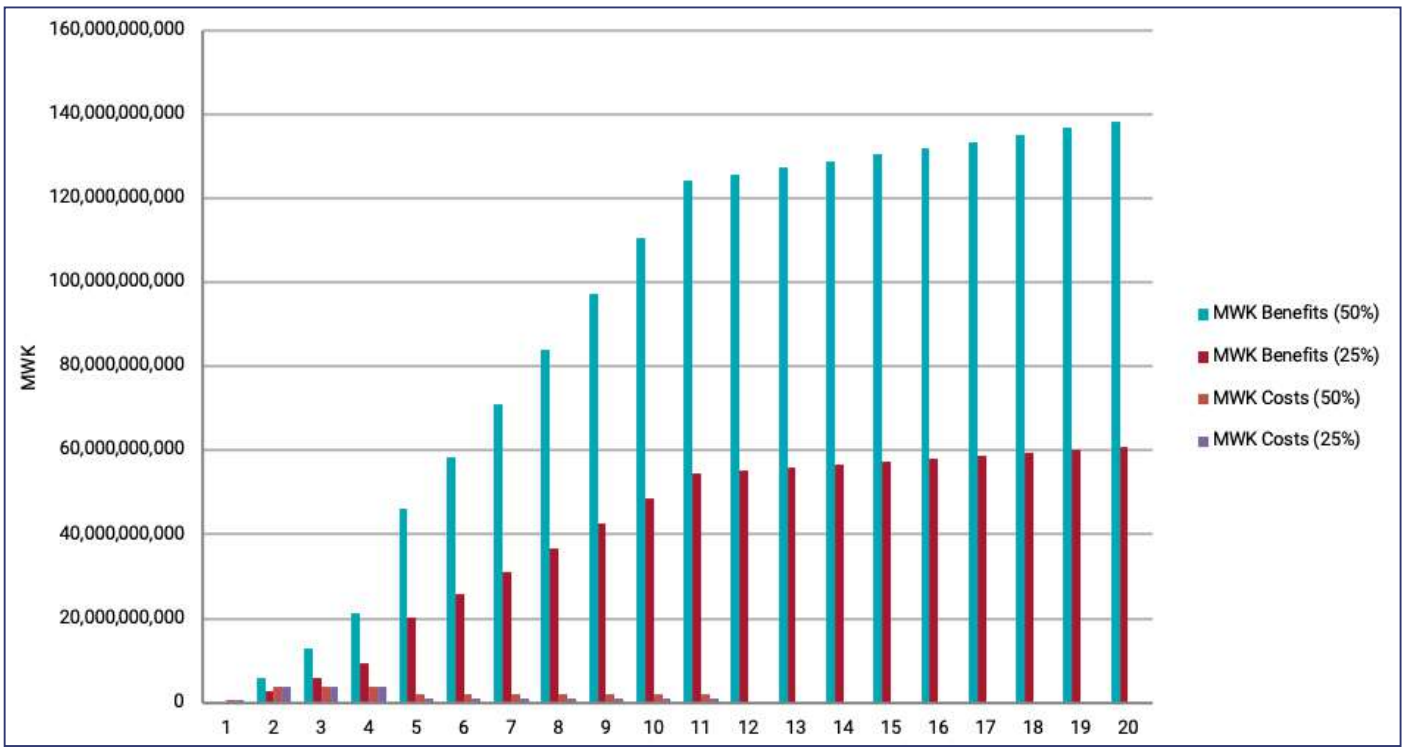
Table 2: Results of Analysis

Discount Rate	NPV of Expected Benefits (Billion MWK)	NPV of Expected Costs (Billion MWK)	Benefit-Cost Ratio
5%	1019	20	51
8%	746	18	41
14%	429	15	29

Similar results were found in the CCC's Haiti Priorities Project: power sector reform leading to reduced total losses was estimated to have a BCR of 22. Belt et al. (2017) found that reduced technical losses had great benefits to Haiti in general and that improvements in non-technical losses had very significant benefits to Electricité d'Haïti, the local utility.

Figure 5 below demonstrates benefits and costs over time at 50% and 25% success rates. Figure 5 demonstrates that benefits far outweigh the costs of this project even at lower rates of success. Furthermore, it is important to note that costs are impacted by the probability of implementation success because if the project does not lead to improvements in the first five years, the investments pertaining to the second five-year period will not continue.

Figure 5: Benefits and Costs Over Time at Different Levels of Implementation Success



5. Conclusion and discussion

The goal of this analysis was to identify interventions that would improve the reliability of electricity supply in Malawi. This analysis highlights critical issues facing the power sector in Malawi today and offers a solution to these challenges based on the evidence in multiple countries that have incorporated technical assistance.

While Malawi's power sector has made large improvements in the past five years, there were concerns that many of the improvements were not sustainable and could be reversed if key issues were not addressed, particularly important when considering Malawi's goals to expand coverage to 50%.

The CBA results show that the benefits of this project outweigh the costs even at the highest risks of failure. Ensuring an efficient and reliable power supply will have wide-ranging impacts in the social sectors (i.e. health and education), as well as on business investment.

5.1 Sensitivity Analysis

The following section details the results of the sensitivity analysis. To ensure our research results were robust, we tested the sensitivity of our model to key parameters. The parameters tested include:

- Years until reversal
- Average length of PPAs
- Reduction in power costs due to ICB
- The coping cost of businesses
- Power generation scenarios
- Different levels of management improvement (Intervention implementation success)

The first factor tested was the years until reversal. This parameter is used to estimate the technical losses without intervention and refers to the length of time it takes for technical losses to increase by 5%. The years until reversal has a large impact on the BCR, however, the benefit of reduced technical losses is so large that the project remains largely positive across the range.

Table 3: Impact of Years until Reversal on BCR

Years until Reversal	BCR
10	41
15	33
20	25

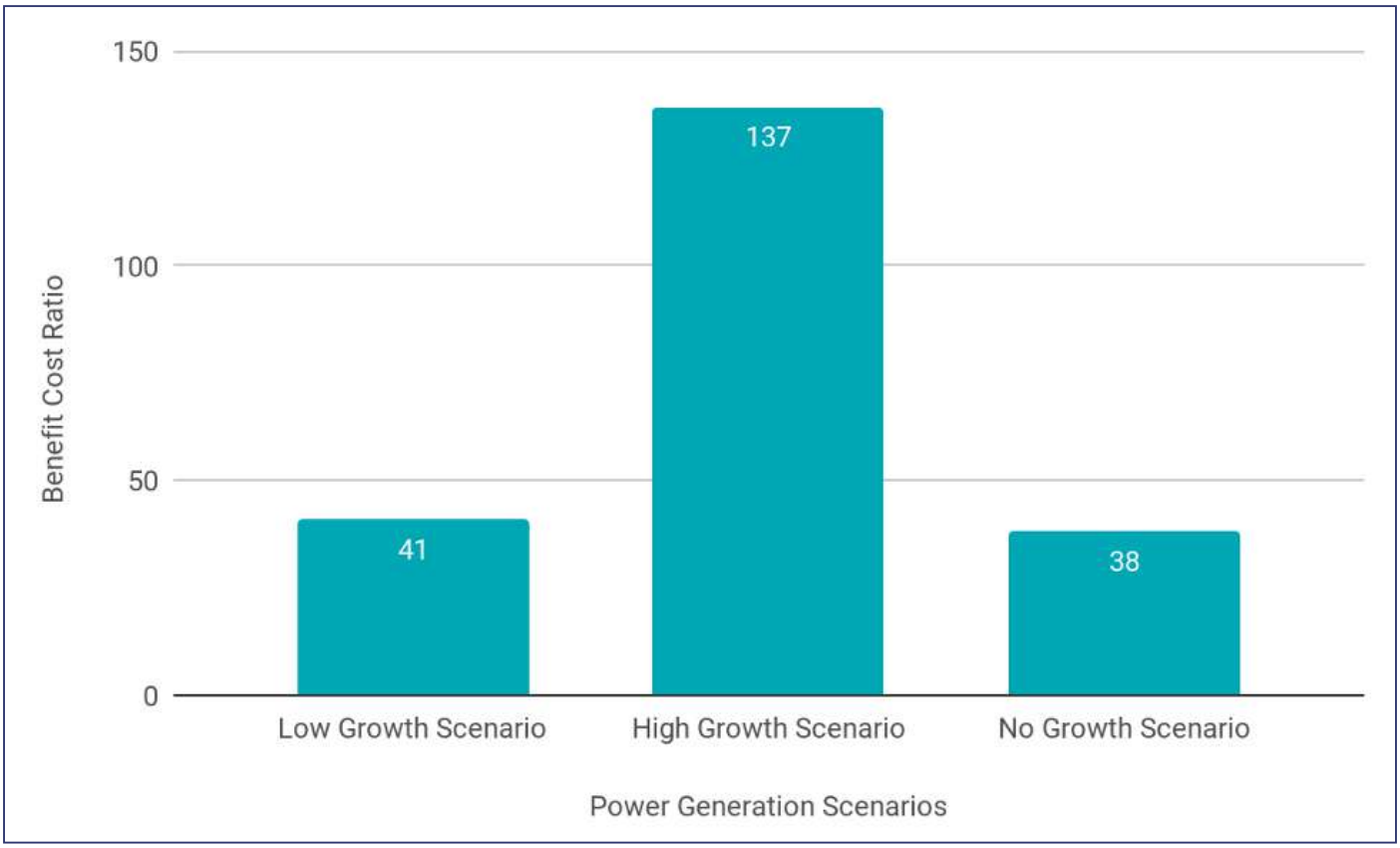
Another factor in the sensitivity analysis was the coping cost of businesses. Our analysis valued the reduced technical losses with the intervention with the assumption that the power saved can be used by businesses. Steinbuks and Foster (2010) estimate of businesses' cost of self-generation showed that the cost to businesses was close to ten times greater than the cost of power from the grid. We conducted sensitivity analysis on this value due to the large impact of reduced technical losses on the results.

Table 4: Sensitivity Analysis of Coping Cost of Businesses

Coping Cost (2020 USD)	BCR
2.09	41
1.67	33
1.05	21
0.42	9
0.16	5

Another uncertainty we tested was the future of power generation in Malawi. In 2018, ESCOM predicted the growth of power generation over the next four years. We used these estimates for the first four years of the project. Our first scenario for power generation is the base case and assumes low growth. It assumes that after the projected growth over the next four years, growth will continue at the historical rate of the past ten years. The second scenario is optimistic with high growth. This scenario assumes that after the four years, growth in power generation will grow to accommodate the increased demand associated with reaching 50% coverage by 2030. The third scenario assumes no growth will occur after the projections estimated by ESCOM, which represents a slight underestimation of the benefits.

Figure 7: Sensitivity Analysis of Power Generation Scenarios



The first scenario, which was our default assumption for the model, has a BCR of 41. When we assume that power generation will expand to support reaching Malawi's target of 50% coverage, the BCR is increased to 137. With the conservative estimate of no growth after the projected increases by ESCOM, the BCR is 38.

Due to the risk of this project failing, we added a parameter for different levels of success resulting from the operational and governance maintenance and improvements resulting from the intervention. This parameter was added because the intervention requires changing of practices, legal frameworks, and improving corporate governance. Interventions such as this carry risk as their effectiveness can be impeded by lack of political will, corruption or incompetence. We conducted the analysis assuming that the improvements would only result in ESCOM achieving 50% of efficiency and capability level demonstrated by the MCC. We also found the level of success where benefits and costs broke even. Our analysis looking at the level of success in implementation showed that this project is worthwhile even with high-risk levels. The results showed that the benefits costs even if the success level is as low as 1%.

Table 5: Sensitivity Analysis of different levels of management improvement (Intervention implementation success)

Success rate of management's efforts	Benefit-Cost Ratio
1%	1
25%	26
50%	41
75%	51
100%	58

Limitations

This study was based on a literature review of interventions in the power sector with only a limited time to engage local consultants and sector experts. This analysis should be considered a pre-feasibility analysis. The benefits of this analysis are also based on assumed

changes to technical losses. This assumption was based on the concern over sustainability from MCC Power Sector Reforms and the fact that unbundling is not a recommended practice for a system the size of Malawi's. The true change in technical losses needs further research as the authors had limited resources to investigate the state of technical losses. Nevertheless, the results of this study suggest sizeable returns to the intervention even under conservative scenarios.

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