Chapter 19
Energy Policy as a Tool for Promoting Power System Resilience: Malawi's Challenges and Potential Solutions

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Abstract A constant production and delivery of electricity is crucial to the functioning of the society. Power systems, however, suffer from either physical, institutional or community level challenges under climate change. Specifically, Malawi is exposed to both climatic and geologic hazards. One of the guiding principles of the needs assessment and recovery strategy is to move from response to long term resilience. The national energy policy (NEP) is considered as one of the drivers of long-term power system resilience (PSR). Understanding the status of NEP is critical in coming up with long term resilience solutions because the qualitative evaluation in this case considers information about risks, the perceived severity of risks and possible impacts of shocks. Although prior studies contributed significantly to the resilience of electricity systems, none of those studies explored the possibility of the NEP being a critical key in promoting the resilience of the electricity sector to extreme weather events. This novel study, therefore, assessed the capacity of the NEP to promote infrastructure and institutional PSR. It also identified challenges regarding the capability of the policy to support PSR. Finally, the study suggested key policy solutions to the identified challenges. Content and thematic analysis were used to analyse the status of energy policy. While the capacity of the policy to promote infrastructural resilience was assessed by evaluating the level of technical policy implementations and status of electricity supply, institutional resilience's capacity was determined through legal and capacity building policy implementations. Notably, the NEP fails to support PSR. Resilience policies, energy policy financing, energy

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J. D. Nixon et al. (eds.), *Energy and Sustainable Futures: Proceedings of the 3rd ICESF, 2022*, Springer Proceedings in Energy, https://doi.org/10.1007/978-3-031-30960-1_19

policy management, coordination with key stakeholders, politics, energy data and capacity of the Ministry of energy are critical issues.

Keywords Infrastructure resilience · Institutional resilience · Policy financing · Resilience policies · Energy policy monitoring · Capacity · Energy data · Coordination

19.1 Introduction

A constant production and delivery of electricity is crucial to the functioning of the society. Energy plays a vital role in sustainable livelihoods and socioeconomic development [1]. Apart from servicing the other sectors, the energy sector is supposed to be among the sectors that contribute significantly to the country's GDP through exports of its products. However, surplus energy supply is one of the challenges that Malawi is facing, as its supplies are less than the projected demand [2–4]. Meeting sufficient energy needs for Malawians is becoming more challenging. The renewable energy (RE) role to the energy mix is also still low [5]. In addition to low energy access, Malawi is exposed to both climatic and geologic hazards [6–8] given its location along the great African Rift valley. Extreme weather events pose an enormous and increasing threat to the nation's electric power systems (PS) and the associated socio-economic systems that depend on the reliable delivery of electric power [9]. In January 2022, Malawi was severely hit by Tropical Cyclone Ana which caused national blackout due to lost power generation and transmission systems. One hundred thirty (130) MW of electricity generation were lost [10] and many transmission lines were brought down. This overwhelmed the mitigation measures that were put in place [11]. PS suffer from either physical, institutional or community level challenges under climate change (CC) hence, the need for appropriate adaptation strategies [12]. One of the guiding principles of the needs assessment and recovery strategy is to move from response to long term resilience [7].

Different authors [13–34] presented a range of power system resilience (PSR) definitions. Having reviewed the range of definitions, the grid resilience definition is proposed. It is the ability of an interconnected network of either components, institutions, grid operators or stakeholders to adequately plan for resilience, avoid adverse impacts of hazards, adapt to extreme disasters and transform into new stable zones. In doing so, the impact of threats and related disasters will be minimised, and systems will be restored quickly. Where appropriate, systems will be improved. Finally, disaster risk factors and vulnerability of the grid system to actual or expected impacts of hazards will be reduced in a cost-effective way. Resilient systems should have a maximum diversity of supply sources and should avoid reliance on a limited set of power supplies. In addition, systems should be sufficiently flexible to react rapidly to events and to alter working processes even in short times [35]. Further, priorities for supplying diverse loads ought to be well-known [36]. Erker et al. [37] argued that a resilient system should not be exposed to risks or potential risks, is efficient,

diverse and has redundant units or functions. The rise of power outages caused by extreme weather events and the frequency of extreme weather events has motivated the study of PSR [38]. The development of PSR assessment and enhancement tools, methods, approaches and/or guidelines is also another cause for PSR studies.

PSR can be evaluated either quantitatively or qualitatively [14, 18, 19, 39]. References [13, 14, 16, 20, 26, 27, 33, 36, 38, 40–47] evaluated PSR by quantifying the resilience of electricity networks to extreme events. Some suggested measures to enhance the resilience of the PS. While others [17, 27, 35, 48–51] looked at structural challenges and measures, [18, 29, 45, 52–59] considered operational strategies. Although all these studies contributed significantly to the resilience of electricity systems, none of the prior studies explored the possibility of the energy policy being a critical key in promoting the PSR. The national energy policy (NEP) is considered as one of the drivers of PSR [12]. According to [60], NEP is one of the dimensions in the testing of the *transformative resilience theory* where policy performance is considered one of the resilience indicators. This novel study, therefore, (1) assesses the capacity of the NEP to promote infrastructure and institutional PSR, (2) identifies implementation challenges regarding capability of the policy to support PSR and (3) suggests key policy solutions to PSR challenges of the NEP and thus the accomplishment of SDG 7 [61]. After the introduction, Sect. 19.2 is the methodology, followed by results and discussions in Sect. 19.3 under distinct sub-topics. Conclusions are drawn in Sect. 19.4.

19.2 Methodology

The study methodology was in two stages, one, data collection and extraction and two, data analysis. Data collection was through observations, review of documents and in-depth interviews. The population that qualified as subjects for this study included all individuals that have expert knowledge and hold key positions in the energy sector, grid operator, and power generating company. In this case, the study used purposive sampling where subjects are selected based on some characteristic poses that are predetermined before the study [84]. This was also to identify respondents who would provide relevant and critical information that would serve to answer the questions of this study. For in-depth interviews, semi-structured interview guide was used to collect data for the status of NEP. To analyse data, both content and thematic analyses were used. To evaluate the potential risks to infrastructural and institutional resilience, the approaches of [37, 62] were adopted. In view of this, the capacity of the Policy to promote PSR was evaluated by examining diversity, exposure, and efficiency. These are functions of preparation, anticipation, absorption, adaptation and transformation. While the capacity of the Policy to promote infrastructural resilience was assessed by evaluating the level of technical policy implementations and through status of energy supply, institutional resilience's capacity was determined through legal and capacity building policy implementations. This approach was adopted because effective address of preconditions that cause PS stresses is key to making the PS more

resilient [14]. Technical implementations that were considered are energy access, off grid and energy efficiency targets. These targets and the status of electricity supply together entail the level of infrastructure preparedness to mitigate impacts of CC. In addition, these also determine the potential to absorb, adapt or transform under extreme PS stresses. Anticipatory governance and long-term policy vision are critical in the adjustment of current behaviour to address future PS challenges [37]. It is important, therefore, to evaluate legal implementations to address regulatory uncertainties that compromise infrastructure improvement and modernisation. Capacity building enables institutions in moderating future disruptions. It is important to note that this study's scope was not to evaluate the provision of these variables in the Policy but their implementation to promote grid resilience. This is because preliminary policy review suggested that most of these are provided for. A key issue was to compare the provision against achieved targets (status of the NEP). If implementation is lagging, then the Policy is failing to promote one of the key functions of resilience. To identify the challenges of the Policy, themes were generated from interview responses following this study's investigations of the reasons for the implementation challenges. Solutions to the challenges were proposed by suggesting mitigation measures to the identified challenges, in addition to expert feedback. The major limitation of this approach was data scarcity. Some variables could not be extensively evaluated due to data availability challenges.

19.3 Results and Discussions

19.3.1 The Structure of Electricity Supply

Malawi's current electricity generation mix is divergent from the neighbouring countries and world trends where electricity generation from fossils is dominant (Table 19.1). Malawi has about 401.15 MW, 81.3 MW and 53.22 MW of installed hydro, commissioned solar PV and diesel generator capacities, respectively. A 21 MW Serengeti solar power plant is expected to be commissioned by June 2023. It is important to note that the available capacity is far much less than the installed capacity due to age of the infrastructure, sometimes due to low water levels and recently following a loss of generation due to effects of 2022 Cyclone Ana. Over dependence on hydro electricity generation is a threat to PSR in the wake of CC. Studies indicate that CC is responsible for the increase in frequency, duration, and intensity of extreme weather events [15, 43, 44, 63]. CC is also responsible for rising global temperatures, changes in rainfall patterns, elevated occurrence and strength of drought days, cloudiness, higher winds, and sea-level rise [15, 43, 63–69]. Cold waves, heavy snow and lightning strikes on or near overhead conductors [70] also result from CC. Each of these impacts of CC affects the PS in different ways, at different degrees either on their own or in combination as is usually the case. There is a risk that if Malawi does not receive enough rains or experience again a two-year drought that

Table 19.1 Percentage of Malawi's electricity generation

Energy source	Percent of the total electricity generation in Malawi	Percent of the total electricity generation in Africa	Percent of the total electricity generation for the world
Fossil	9.94	82.44	70.04
Wind	0	2.23	8.25
Solar	15.17	0.99	4.35
Hydro	74.89	11.92	7.71
Nuclear	0	1.68	9.19
Geothermal	0	0.73	0.47

Data source [72]

was experienced in the year 1914, Shire River would stop flowing and there would be power crisis [71]. Emergency Power diesel generator sets (peaking generators) are a source of fossil generation. Due to the deficit in the electricity supply, Malawi government has provided for the interconnection to the Zambian, Mozambican and Tanzanian grids through Southern African Power Pool (SAPP) agreements. There are plans to import 30 MW, 50 MW and 150 MW from Zambia, Mozambique, and Tanzania, respectively, by December 2023 [5]. Further, plans to develop seven (7) new hydropower stations totalling 1073 MW by 2023 and coal fired power plants totalling 620 MW are outlined in [5, 61].

19.3.2 Policy Implementation

Through the current implementation, there has been some improvement in the overall energy sector. This improvement is in line with the priority areas for Malawi's Action Agenda [61]. The following evidence demonstrates the effect of implementing the current NEP. The implementations are categorized into legal, capacity building and technical. Tables 19.2, 19.3 and 19.4 summarise the legal, capacity building and technical implementations, respectively, as of 2021. Table 19.2 presents policy targets that were to either be developed, adopted, reviewed, or enforced. Notably, there were more policy developmental activities than adoptions, reviews and enforcements. Similarly, Table 19.3 presents those that were to either be developed, conducted, or increased.

19.3.2.1 Legal Implementations

See Table 19.2.

19.3.2.2 Capacity Building Implementations

See Table 19.3.

19.3.2.3 Technical Implementations

These are categorized into energy access, off-grid, and energy efficiency targets. Table 19.4 summarises the Policy variable targets against percentage of implementation status for the selected targets that are related to electricity sector. Targets for 2020 (except where explicitly stated otherwise) and the current status are summarised. The dashes (−) mean that data is unavailable. This data depends on the availability of the Malawi energy survey reports whose activity is yet to be conducted. It should be noted that all new domestic connections are fitted with Energy Server Bulbs, LEDs.

19.3.3 Does the Malawi NEP Support PSR?

19.3.3.1 Infrastructure Resilience

This study revealed that energy access, off-grid, and energy efficiency targets were not adequately met. This has a bearing on infrastructure resilience because these targets

Table 19.2 Legal implementations

Policy targets	Developments	Adoptions	Reviews	Enforcements
Activities undertaken	Mini grid framework Lifeline tariffs Policies facilitating expediting of customer connections Legislation banning illegal production of charcoal Guidelines for franchising of liquid fuels outlets Tax waivers on gas to support the initial stages of introducing and promoting LPG, biogas, and natural gas	Policies facilitating outsourcing of construction works by distribution licensees Global tracking framework	Grid code	Electricity act to unbundle electricity supply corporation of Malawi (ESCOM)

Data source [73]

Table 19.3 Capacity building implementations

Policy targets	Developments	Awareness	Increment
Activities undertaken	RE capacity building plan Biomass Energy Technologies Training Strategy Nuclear Science and Materials Undergraduate Programs in some public universities DSM awareness materials	Safe use of Liquid Petroleum and Gas (LPG), biogas, and natural gas Household campaigns and distribution of LEDs Demand Side Management (DSM) campaigns	Number of training institutions implementing RETs

Data source [73]

are key to resilience enhancement. *Capacity expansion* is one of the long-term grid enhancement measures [75]. It allows for peak load transferring or shifting when there is generation loss in some parts to avoid overloading the substations. Notably, there is stagnation in the development of potential sites and other sources of electricity generation. Out of the proposed potential hydro sites, only less than 5% of the planned development was commissioned (Tedzani IV). By 2021, at least 50% of the target should have been developed to achieve the 2023 completion target. Three coal fired power plants were planned to be fully operational by 2023, adding 620 MW to the national grid. By 2021, only environmental impact studies for one were completed. Approximately 38% of the proposed solar power plants was commissioned. Although this is a good development, increase in intermittent generation needs adequate firm capacity to avoid frequency disturbances. There should be a corresponding increase in base generation like hydro, nuclear or thermal. Household biogas for cooking was piloted in 8 districts installing 80 systems, representing 14% of the 2020 projected target, and 4% of the 2030 target. Ideally, approximately 140 biogas plants were to be piloted per year if the 2030 target was to be met. Failure to achieve these targets decreases the *capacity mix* which was proposed by Handayani et al. [76] as one of the CC adaptation measures for PSR. Low percentage of RE to total energy in the country is another sign of un resilient systems [60]. The results further suggested a lack of *diversity* in electricity generation sources. Being a system that is almost wholly hydro-based, this exposes the PS to severe impacts of CC like droughts. *Off-grids* like micro grids are the mostly used *smart resilience enhancement measures* [27, 32, 77]. Microgrids take part in emergency response by supplying critical loads or essential. The T&D losses are approximately 19.5%—still off their targets. Efficient T&D structures limit the degree of impact during extreme events. An inefficient T&D system derates faster than an efficient one. Energy audits are expected to unmask system inefficiencies. Although regular audits were planned for public institutions especially in the health sector, only 28 were conducted in health, parliament and

Table 19.4 Policy technical implementations

Area	Policy variable	Target	Implementation Status (%)
Energy access	Hydropower plants	1092 MW by 2023	< 5
	Solar PV plants	160 MW	38
	Coal fired power plants	620 MW by 2023	0
	No. of companies registered in LPG stoves distribution	20	>100
	LPG stoves	15,000	–
	No. of improved cookstoves distributed	2 million	> 100
	No. of household biogas piloted	560	14
	No. of solar water heaters	7500	–
	No. of electric cookers installed	94,000	–
	No. of homes/businesses connected to the grid	747,846	66
Off-grid	Mini grids	15 mini grids by 2021 in NEP and 30 mini grids by 2020 in AA	53
	Solar home systems and Pico solar systems	1.5 million	80 in 2018
Energy efficiency	Combined transmission and distribution (T&D) losses	17%	15%
	Installed prepaid/smart meters	564,000	83
	LEDs	2,750,000	–
	Energy efficient (EE) barns	2000	–
	Energy audits	Regular energy audits in institutions especially health facilities	–

Data sources [73, 74]

government offices. Inefficiencies reduce the current carrying capacity which consequently raise electricity demand [67]. Installation of smart meters is short by almost 17%. Data for the number of LEDs, EE barns, solar water heaters installed was not available. LEDs would relieve the grid from the demand pressure. In view of the above, failure of the Policy technical implementations predisposes the grid to severe impacts of climate change. Although NEP is effective, efficient, equitable and

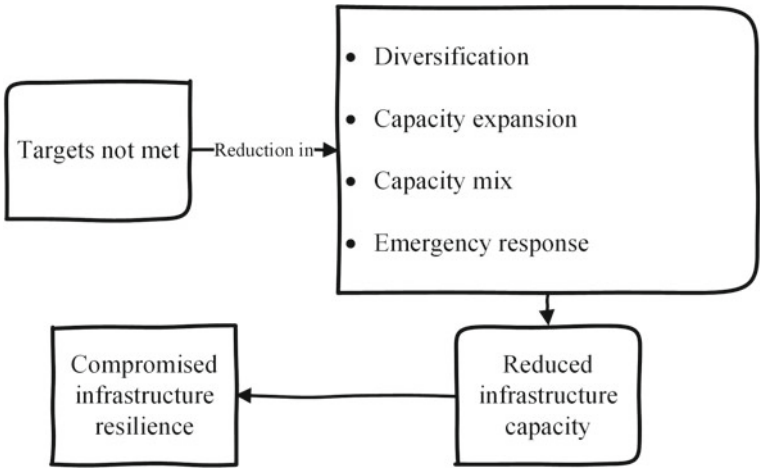

Fig. 19.1 How NEP fails to support infrastructure resilience

institutionary feasible, it fails to support infrastructure resilience adequately. This is visualized in Fig. 19.1.

19.3.3.2 Institutional Resilience

Failure to review, promulgate, amend or develop different sets of standards, models, policies and guidelines in the energy and electricity sector is an institutional resilience setback. What was implemented is insignificant compared with the legal Policy targets. Panteli and Mancarella [43] classified the forms of climate adaptation strategies for PSR into (1) structural, (2) capacity building and (3) institutional. Institutional adaptation strategies are further categorised into economic tools, governance, laws and regulations. Similarly, failure to build capacity and/or recruit enforcement officers is another way of compromising institutional resilience. Failure to develop a bankable document for nuclear power generation investments was observed. Similar observations were noted for the regulations setting minimum standards for coal storage, transportation, importation, usage, marketing and pricing. The bankable document is ideal especially now when the NEP provides for coal fired power plants to increase electricity generation capacity. The document would among other things provide guidelines for optimal orientation of coal stockpiles which are vulnerable to precipitation, wind and temperature variations [78]. Amendment of legislation to include banning importation, distribution and use of incandescent bulbs is still pending. Similarly, the Liquid Fuels and Gas (LPG) Act reviews to facilitate institutional reforms for investments in and utilization of LPG, biogas and natural gas were not conducted. By 2019, the development of bio-fuel pricing model and of an Act to regulate fuel prices through use of transparent and verifiable fuel price adjustment system were supposed to have been completed. In addition, the Net Metering

Policy, appropriate RE regulations under the RE Act and the RE Act were not developed. Finally, the RE standards are yet to be reviewed, three (3) years after their deadline. Policy and regulatory instruments in RE were acknowledged by Fang and Wei [79] as adaptation measures in PS, which can be applied either at enterprise, regional, national, or international level. Further, rescheduling investments, investing more in carbon management technologies and the policy were also suggested in [80] as resilience enhancement measures. Similarly, RE plants to compensate for the uncertainty in hydropower generation are key PSR improvement strategies. Panteli and Mancarella [43] proposed capacity building, which was further classified into educational, informational, or behavioural adaptation as one of the PSR enhancement approaches. Sovacool [12] recommended, among others, training policy makers as a way of promoting institutional resilience. Education and awareness to achieve community resilience to impacts of CC were also recommended. Lack of provision for PSR awareness in the Policy and emergency response plans is another way of compromising institutional resilience. In addition, by 2020, Malawi government was supposed to have recruited district energy officers (DEOs) responsible for enforcement of efficient cookstoves. RETs like biogas, improved cookstoves, micro hydro and solar power were also recommended by Sapkota et al. [81] as a way of rural adaptation to CC. These do not only reduce traditional biomass use but also carbon dioxide emissions. Use of these also reduces pressure from the grid. The results suggested that NEP also fails to support institutional resilience adequately. This is summarized in Fig. 19.2.

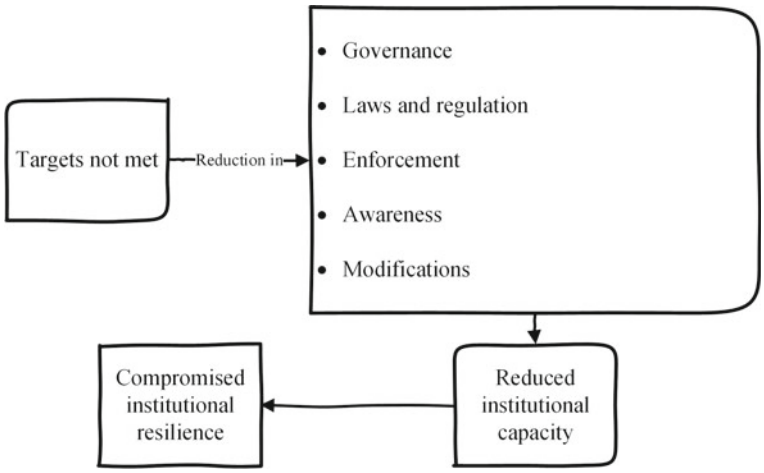

Fig. 19.2 How NEP fails to support institutional resilience

19.3.4 Challenges and Potential Solutions (Improvements) of Malawi's NEP

Policy evaluation indicates that some measures to achieve SDG 7 have previously been implemented in Malawi. However, some unresolved concerns departing from the guiding principles and policy statements of Malawi's NEP and the international initiative for affordable, reliable, sustainable, and modern energy for all remain. These in turn compromise the resilience of the PS and electricity sector in general. Energy policy financing, energy policy management, resilience building policies, coordination of key stakeholders, politics, energy data and capacity of the Ministry of energy (MoE) are critical issues in Malawi. Addressing these preconditions is key in making the grid more resilient [14]. In this section, we summarise the unresolved issues which were identified, and formulate key policy solutions for the problems as follows.

19.3.4.1 Energy Policy Financing

Much as some of the commendable progress is noted, a significant portion of measures are behind their scheduled time frames. The stagnation in development of potential sites and other sources of electricity generation is worrisome because poor infrastructure development compromises infrastructure resilience [60]. For the proposed power plants, the developers are still seeking finances for the development activities [73]. Implementation of Malawi's NEP 2018 needs sufficient human, financial, material and technical resources. Most of the activities that have not been completed according to their planned time frames lack financing [73]. Some capacity building exercises also lack funding. The follow-up on targets is also not done due to financial constraints. Desirable resources were indicated in the Policy but what the Government provides through the Ministry of Finance (MoF) is not adequate. There is a need for deliberate actions by the government to finance the activities of the energy policy—*Energy Policy Financing*. Government, through MoF should have the core responsibility of committing adequate financial resources for the implementation of the Policy [82]. The MoF should consider putting aside a budget to support the energy sector. The funding would also help with follow-up of activities of the NEP. This is in line with [85] where lack of financial resources implies that laws will not be enforced, services will not be provided, and reasonable regulations will not be developed. Financial resources also help with the acquisition of land, equipment, and buildings. The government may benefit from reaching out to different foreign investors through MoF. Another thing to be considered is for the government to increase budgetary allocation for the energy sector. The energy sector currently relies on donor funding. An adequate budget would facilitate the development of the entire energy sector.

19.3.4.2 Resilience Policies

It was observed that existing policies and regulations were inadequate to respond to the complex challenges presented by extreme events. The NEP has eight main priority areas: electricity, biomass, petroleum fuels, bioethanol and other biofuels, liquid petroleum, gas, biogas and natural gas, coal, nuclear energy and DSM. Although these areas indirectly support PSR, resilience is not prioritized in the Policy. Prioritization of resilience in energy policies or existence of resilience policies provide the preventive and anticipative capacities which enable institutions to prepare for and to commit resources as well as to formulate legal and contractual frameworks within which they would operate during an unusual event [83]. These capacities, ensure that the impacts resulting from such occurrences are greatly reduced by reducing both the vulnerability and exposure of the PS to extreme events and by creating a proactive system in which present development actions inherently address future risks. The next Policy review should emphasize the inclusion of resilience of PS.

19.3.4.3 Energy Policy Monitoring/Management

It is appreciated that some of the planned activities are not achieved within their proposed time frames due to financial constraints. However, some have just lagged for no reason. Some 2019 Policy targets were still unattained by 2021, two years down the line. Most of activities in the NEP are supposed to be completed by 2023 and others by 2035 in the long term. Most of the 2023 targeted activities are yet to be commenced. It is unlikely that targeted time frames will be achieved. Although the Malawi's NEP is scheduled to be reviewed every five years, this study revealed that it takes longer than that, with the main reason being financial constraints. However, other views consider that this is attributable to lack of seriousness from responsible personnel. Often, the personnel are just good at setting targets which leads to over-ambitious targets that are often not implementable. [85] identified some other obstacles that affect policy implementation in developing countries. Among them were insufficient definition of goals, over-ambitious policy goals, and choice of unsuitable organizational structure in implementation. Regarding over-ambition in policy making, in developing countries, several policies tend to be over-ambitious, broad, and basic in nature. This is because of some of those developing countries are being inspired by special conditions, usually defined by developed countries that affect how programmes and policy goals are decided, in exchange for government funding. Further to the above issues, the lack of a framework to help with checking or tracking NEP is another critical issue. The absence of a policy tracking framework has also contributed to unachieved monitoring and evaluation. The Policy has an implementation and evaluation plan, but this is embedded in the Annexes of the Policy. Implementation tracking framework may offer competitive benefits if it is a standalone document under some legal custodians. One of the many reasons for Policy implementation failure is the model of functionality within the MoE. Although decentralization is considered one of the ideal approaches to management functions,

the MoE, who is the custodian of the NEP, works centrally. This puts pressure on the personnel. To curb these challenges highlighted above, different solutions are suggested. First, regular monitoring and evaluation are needed to inform custodians of the next steps. The civil society organisations can also play a part in monitoring implementation and promoting unique approaches to enhance implementation, working as watchdogs to ensure that funding is allocated, and appropriate activities are carried out [86]. The interim reviews should look at what was supposed to be achieved in a particular year. This also works well with mindset change. Mindset change can be advocated through different approaches. Learning from other nations that have successfully implemented their energy policies is one way in addition to mindset change programmes that can be introduced by the government through the ministry of information and civic education. The feeling of not owning the Policy leaves a lot of things unattended to. Also, the setting of realistic goals heavily depends on meaningful engagement with different key stakeholders. For example, legal targets are supposed to be set with serious consultations with the Ministry of Justice. Finally, decentralization of the MoE may offer Policy managerial/administrative benefits. The MoE may also benefit from employing more energy officers in different Policy areas.

19.3.4.4 Coordination with key stakeholders

Policy implementation cannot be achieved by the MoE alone. There is a need for collaborative efforts among different stakeholders for the implementation of the NEP to take place. Communication is an important component for successful implementation of Policy [85]. Through communication, instructions to implement policies are anticipated to be conveyed to the suitable personnel in a transparent manner while such instructions must be precise and coherent. Insufficient information can result in a misunderstanding on the part of the implementors who may be confused as to what exactly is required of them. In effect, implementation directives that are not communicated, that are twisted in communication, that are ambiguous, or that are conflicting may cause serious barriers to policy implementation [85, 86]. On the other hand, orders that are too specific may impede implementation by suppressing innovation and flexibility [85]. In Malawi, stakeholders within the sector do not specifically own policy statements. This has led to some activities not to be achieved. Most stakeholders assume that every statement is the responsibility of the MoE. In addition to this, there is no 100% linkage between key sectors such as the Ministries of Treasury and Justice. There are Policy statements that directly require the involvement of these key sectors. Further, policy plans (targets) depend on other stakeholders. For example, investors are not coming to invest in coal fired power plants. Only memorandums of understanding have so far been signed. The government is on its own because foreign investors consider coal damaging to the environment. This has caused implementation failure due to lack of donor funds. A lack of coordination with key stakeholders has also led to unavailability of energy data. Some of the data to determine implementation of NEP was not available at the MoE. The data was

with responsible stakeholders such as ESCOM, Malawi energy regulatory authority (MERA) and the National Statistical Office (NSO). This data was supposed to be publicly available. However, the MoE does not have a database of the activities of the energy policy. This is a drawback in policy implementation because the current energy data informs next decisions. Accurate energy data is also a basis for research and development activities. Engaging key policy stakeholders during policy target setting phase may encourage policy statements ownership. In addition, collaboration with other ministries or departments such as mining may benefit the MoE to solve energy data challenges. One of the collaborative agreements would be to have a common database, under the MoE but whose input can be done from different sectors or ministries. Another agreement would be for responsible stakeholders to commit to providing their services, for example the MoF committing to providing financial resources.

19.3.4.5 Politics

The study reveals that lack of political will is one of the contributing factors for the policy implementation failure. This owes to the fact that in the implementation process, political resources are needed [86]. This is in line with [85], where disposition or attitude is an additional significant factor that affects policy implementation. In Malawi's context, energy investment timelines are different from political timelines. Energy investments take long unlike the political timelines which are 5-year terms. Because political leaders are focusing on projects or activities that will lead to some tangible outputs in 5 years, Policy activities tend not to be prioritized. This is why some energy investment directions are not politically supported i.e., shot down by parliamentarians. A policy that operates opposite to the manifesto of the government in power may suffer at the implementation phase because it may lack support, both financial and organisational [85]. As national political environment changes, some policy perspectives also change, in turn affecting which players are involved, which policy decisions are made, and what processes take place at various levels, including the operational and service delivery levels [86]. The other political problem is that energy is not regarded as a critical infrastructure, hence not prioritised. This is why there is some significant political interference in the energy sector, especially in rural electrification. It is high time that political leaders supported the Policy by taking part in political deliberations that encourage energy investments. The political leaders should be willing to develop the energy sector by advocating for the implementation of the Policy activities. Also, there is need to advocate for energy as a critical infrastructure. State political officials may benefit from policy learning related to the re-construction of policy challenges and goals. In some cases, learning means assessment of political viability with respect to policy activity and the political price to be paid for implementation [86].

19.3.4.6 Energy data

The study suggests that energy statistics or data is important not only for research and development but for informing policy formulation, policy reviews and decision making [87, 88]. This calls for high level understanding of energy data. The availability of energy data relies on energy surveys. In Malawi, surveys rely on the NSO. This results in limited survey questions because NSO surveys are generic in nature. There is a need for energy-dedicated surveys. These energy dedicated surveys may be conducted by the MoE in collaboration with academia. These energy-dedicated surveys will help in managing unrealistic or ambiguity of Policy targets. As stated in 19.3.4.4, the MoE does not have a database. The Ministry may need to compile annual energy statistics. These energy statistics may come from dedicated energy surveys and databases from energy companies. These statistics provide an energy balance which is a major tool in the implementation of the energy policy.

19.3.4.7 Capacity of the MoE

This study revealed that the MoE lacks some capacity to champion the Policy. There was insufficient human capacity in terms of numbers, evidenced by lots of vacant positions. The capacity to enforce was also not there. This all goes down to vacant positions since the 28 District Energy Officers who were to be recruited by 2019 to enforce the Policy are yet to be employed. Capacity development programs on how the Ministry can undertake various activities of the Policy may be beneficial. Capacity building on how to interpret NEP may also help with the implementation challenge. Recruitment of additional energy officers is long overdue. Human resources such as adequate number of staff who are well equipped to carry out the implementation, relevant and adequate information on implementation process, the authority to ensure that policies are carried out as they are intended, may be deemed necessary for the successful implementation of the policy [85]. Without sufficient human resources it means that laws will not be enforced, services will not be provided, and reasonable regulations will not be developed. Since the capacity of the MoE also depends on various key stakeholders, sensitizing these stakeholders on their expected roles and criticality of the energy sector is another positive approach to dealing with implementation challenges. Some Policy targets may need an increase in various capacities, especially in numbers. The challenges and potential solutions discussed above are summarized in Table 19.5.

19.4 Conclusion and Future Research Direction

Energy plays a vital role in sustainable livelihoods and socioeconomic development. The PS, however, suffers from different challenges under CC hence, the need for appropriate adaptation strategies. This study was conducted to examine the policy

Table 19.5 Summary of Policy implementation challenges and potential solution

Challenges	Potential solutions
Lack of funding	Energy policy financing [82, 85]
Inadequacy of existing Policy to respond to complex challenges presented by the extreme events	Resilience policies [83]
Lack of policy administration, monitoring and clear policy targets	Energy policy management [85, 86]
Lack of coordination with key stakeholders	Meaningful stakeholder involvement [85, 86]
Lack of political will and political interference	Policy learning [86]
Lack of statistical energy data	Compilation of annual energy statistics [87, 88]
Incapacitation of MoE to champion the Policy	Capacity building [85]

challenges that could compromise the resilience of the PS and to suggest potential solutions. In addition, the capacity of the NEP to promote PSR was examined. Study revealed that Malawi's current electricity generation mix is divergent from the neighbouring and world trends where electricity generation from fossils is dominant. Almost 75% of Malawi's electricity generation is from hydro whose 99% of generating plants are cascaded on one river. This exposes the PS to severe impacts of CC like drought. Through current implementation, there has been some improvement in the overall energy sector. This improvement is in line with the priority areas for Malawi's Action Agenda. *The development of some regulatory frameworks*, *increase in electricity generation capacity*, *increased utilization of improved biomass technologies*, *provision of incentives to promote adoption of alternative energy sources*, *increased uptake, or adoption of alternative means of cooking energy sources to biomass*, *increased production of biofuels*, and *increase in number of institutions conducting energy efficiency interventions* and many more contribute to the fair progress. The results suggested that although NEP is effective, efficient, equitable and institutionary feasible, it fails to support both institutional and infrastructure resilience adequately. Most of the activities that have not been completed according to their planned time frames lack financing. It was also observed that existing policies and regulations were inadequate to respond to the complex challenges presented by extreme events. Lack of policy monitoring largely contributes to non-implementation. Other implementation challenges are incapacitation of the MoE in different areas, lack of energy data, political interference and lack of coordination with key stakeholders. To improve the infrastructure and institutional resilience, policy enhancement measures were proposed. Energy policy financing, resilience policies, guidelines and/or frameworks enhancing energy policy tracking, capacity building, compilation of annual energy statistics, policy learning and meaningful stakeholder engagement are possible improvement approaches. In summary, a supportive policy environment can be regarded as one of the cornerstones of improved and effective policy implementation for PSR. In further studies, the resilience of an

entire energy sector with respect to policy's capacity will be investigated. In addition, comparison of Malawi's NEP to other sub-Saharan policies will also be conducted.

Acknowledgements The author would like to acknowledge Commonwealth Scholarship Commission and Schlumberger Foundation Faculty for The Future for the Fellowship for the Ph.D. research support. Sincere appreciations are also extended to the Electricity Supply Corporation of Malawi and the Department of Energy Affairs for granting this research with useful data.

References

1. M. Jeuland et al., Is energy the golden thread? A systematic review of the impacts of modern and traditional energy use in low- and middle-income countries. Renew. Sustain. Energy Rev. **135** (2021). https://doi.org/10.1016/J.RSER.2020.110406
2. Electricity Generation Company (Malawi) Limited—Generating Power for Generations. https://www.egenco.mw/. Accessed 28 Jul 2021
3. Electricity Supply Corporation of Malawi Limited (ESCOM). http://www.escom.mw/. Accessed 28 Jul 2021
4. C. Zalengera, R.E. Blanchard, P.C. Eames, A.M. Juma, M.L. Chitawo, K.T. Gondwe, Overview of the Malawi energy situation and a PESTLE analysis for sustainable development of renewable energy. Renew. Sustain. Energy Rev. **38**, 335–347 (2014). https://doi.org/10.1016/J.RSER.2014.05.050
5. Government of Malawi, in *Malawi National Energy Policy* (2018)
6. Government of Malawi, in *Malawi Drought 2015–2016: Post-Disaster Needs Assessment* (2016). https://openknowledge.worldbank.org/handle/10986/25781. Accessed 10 Jul 2021
7. Government of Malawi, in *Malawi 2015 Floods Post Disaster Needs Assessment Report* (2015)
8. Government of Malawi, in *Malawi 2019 Floods Post Disaster Needs Assessment Report* (2019)
9. Grid Resilience and Intelligence Platform (GRIP)|Grid Modernization Lab Consortium. https://gmlc.doe.gov/projects/1.5.01. Accessed 28 Jul 2021
10. Over K18bln needed to restore 32% of power lost from Kapichira due to Cyclone Ana—Maravi Express—Your Kind of News. Clear and accurate. https://www.maraviexpress.com/over-k18bln-needed-to-restore-32-of-power-lost-from-kapichira-due-to-cyclone-ana/. Accessed 08 Feb 2022
11. A dark, disastrous night after storm Ana—The Nation Online. https://www.mwnation.com/a-dark-disastrous-night-after-storm-ana/. Accessed 08 Feb 2022
12. B.K. Sovacool, Expert views of climate change adaptation in the Maldives. Clim. Change **114**(2), 295–300 (2012). https://doi.org/10.1007/s10584-011-0392-2
13. Y. Yang, W. Tang, Y. Liu, Y. Xin, Q. Wu, Quantitative resilience assessment for power transmission systems under typhoon weather. IEEE Access **6**, 40747–40756 (2018). https://doi.org/10.1109/ACCESS.2018.2858860
14. B. Chiu et al., *Resilience Framework, Methods, and Metrics for the Electricity Sector* (2020)
15. E.L. Ratnam, K.G.H. Baldwin, P. Mancarella, M. Howden, L. Seebeck, Electricity system resilience in a world of increased climate change and cybersecurity risk. Electr. J. **33**(9) (2020). https://doi.org/10.1016/j.tej.2020.106833
16. F. Mujjuni, R. Blanchard, T. Betts, A case for a new approach in theorizing and operationalisation of resilience for electrical systems in developing countries, in *Bhattacharyya, SC, 2021, Proceedings of the Virtual International Conference on Aligning Local Interventions with the UN Sustainable Development Goals* (2021)
17. P. Cicilio et al., Electrical grid resilience framework with uncertainty. Electr. Power Syst. Res. **189** (2020). https://doi.org/10.1016/j.epsr.2020.106801

18. Z. Bie, Y. Lin, G. Li, F. Li, Battling the extreme: a study on the power system resilience. Proc. IEEE **105**(7), 1253–1266 (2017). https://doi.org/10.1109/JPROC.2017.2679040
19. Y. Lin, Z. Bie, A. Qiu, A review of key strategies in realizing power system resilience. Glob. Energy Interconnect. **1**(1), 70–78 (2018). https://doi.org/10.14171/j.2096-5117.gei.2018.01.009
20. H. Zhang, H. Yuan, G. Li, Y. Lin, Quantitative resilience assessment under a tri-stage framework for power systems. Energies (Basel) **11**(6) (2018). https://doi.org/10.3390/en11061427
21. B. Li, D. Ofori-Boateng, Y.R. Gel, J. Zhang, A hybrid approach for transmission grid resilience assessment using reliability metrics and power system local network topology. Sustain. Resilient Infrastruct. **6**(1–2), 26–41 (2021). https://doi.org/10.1080/23789689.2019.1708182
22. N. Bhusal, M. Abdelmalak, M. Kamruzzaman, M. Benidris, Power system resilience: current practices, challenges, and future directions. IEEE Access **8**, 18064–18086 (2020). https://doi.org/10.1109/ACCESS.2020.2968586
23. M. Panteli, P. Mancarella, Modeling and evaluating the resilience of critical electrical power infrastructure to extreme weather events. IEEE Syst. J. **11**(3), 1733–1742 (2017). https://doi.org/10.1109/JSYST.2015.2389272
24. M. Panteli, D.N. Trakas, P. Mancarella, N.D. Hatziargyriou, Power systems resilience assessment: hardening and smart operational enhancement strategies. Proc. IEEE **105**(7), 1202–1213 (2017). https://doi.org/10.1109/JPROC.2017.2691357
25. M. Panteli, P. Mancarella, D.N. Trakas, E. Kyriakides, N.D. Hatziargyriou, Metrics and quantification of operational and infrastructure resilience in power systems. IEEE Trans. Power Syst. **32**(6), 4732–4742 (2017). https://doi.org/10.1109/TPWRS.2017.2664141
26. A. Gholami, T. Shekari, M.H. Amirioun, F. Aminifar, M.H. Amini, A. Sargolzaei, Toward a consensus on the definition and taxonomy of power system resilience. IEEE Access **6**, 32035–32053 (2018). https://doi.org/10.1109/ACCESS.2018.2845378
27. S. Biswas, M.K. Singh, V.A. Centeno, Chance-constrained optimal distribution network partitioning to enhance power grid resilience. IEEE Access **9**, 42169–42181 (2021). https://doi.org/10.1109/ACCESS.2021.3065577
28. E.B. Watson, A.H. Etemadi, Modeling electrical grid resilience under hurricane wind conditions with increased solar and wind power generation. IEEE Trans. Power Syst. **35**(2), 929–937 (2020). https://doi.org/10.1109/TPWRS.2019.2942279
29. J. Wang, W. Zuo, L. Rhode-Barbarigos, X. Lu, J. Wang, Y. Lin, Literature review on modeling and simulation of energy infrastructures from a resilience perspective. Reliab. Eng. Syst. Saf. **183**, 360–373 (2019). https://doi.org/10.1016/j.ress.2018.11.029
30. D.T. Ton, W.-T.P. Wang, A more resilient grid: the U.S. Department of Energy Joins with Stakeholders in an R&D Plan. IEEE Power Energy Mag. (2015). https://doi.org/10.1109/MPE.2015.2397337
31. E. Ciapessoni, D. Cirio, A. Pitto, M. Panteli, M. van Harte, C. Mak, *CIGRE WG C4.47 Defining Power System Resilience* (2019) [Online]. Available: https://e-cigre.org. Accessed: 02 Nov 2021
32. S. Poudel, A. Dubey, Critical load restoration using distributed energy resources for resilient power distribution system. IEEE Trans. Power Syst. **34**(1), 52–63 (2019). https://doi.org/10.1109/TPWRS.2018.2860256
33. H. Raoufi, V. Vahidinasab, K. Mehran, Power systems resilience metrics: a comprehensive review of challenges and outlook. Sustainability (Switz.) **12**(22), 1–24 (2020). https://doi.org/10.3390/su12229698
34. R. Rocchetta, E. Patelli, Assessment of power grid vulnerabilities accounting for stochastic loads and model imprecision. Int. J. Electr. Power Energy Syst. **98**, 219–232 (2018). https://doi.org/10.1016/j.ijepes.2017.11.047
35. M. Ghiasi et al., Resiliency/cost-based optimal design of distribution network to maintain power system stability against physical attacks: a practical study case. IEEE Access **9**, 43862–43875 (2021). https://doi.org/10.1109/ACCESS.2021.3066419
36. H. Gao, Y. Chen, Y. Xu, C.C. Liu, Resilience-oriented critical load restoration using microgrids in distribution systems. IEEE Trans. Smart Grid **7**(6), 2837–2848 (2016). https://doi.org/10.1109/TSG.2016.2550625

37. S. Erker, R. Stangl, G. Stoeglehner, Resilience in the light of energy crises—part I: a framework to conceptualise regional energy resilience. J. Clean. Prod. **164**, 420–433 (2017). https://doi.org/10.1016/J.JCLEPRO.2017.06.163
38. F.H. Jufri, V. Widiputra, J. Jung, State-of-the-art review on power grid resilience to extreme weather events: definitions, frameworks, quantitative assessment methodologies, and enhancement strategies. Appl. Energy **239**, 1049–1065 (2019). https://doi.org/10.1016/j.apenergy.2019.02.017
39. Resilience Measurement Technical Working Group, *Qualitative Data and Subjective Indicators for Resilience Measurement* (2015) [Online]. Available: http://www.fsincop.net/fileadmin/user_upload/fsin/
40. A.M. Amani, M. Jalili, Power grids as complex networks: resilience and reliability analysis. IEEE Access **9**, 119010–119031 (2021). https://doi.org/10.1109/ACCESS.2021.3107492
41. M. Panteli, P. Mancarella, The grid: stronger, bigger, smarter?: Presenting a conceptual framework of power system resilience. IEEE Power Energ. Mag. **13**(3), 58–66 (2015). https://doi.org/10.1109/MPE.2015.2397334
42. X. Liu et al., A planning-oriented resilience assessment framework for transmission systems under typhoon disasters. IEEE Trans. Smart Grid **11**(6), 5431–5441 (2020). https://doi.org/10.1109/TSG.2020.3008228
43. M. Panteli, P. Mancarella, Influence of extreme weather and climate change on the resilience of power systems: impacts and possible mitigation strategies. Electr. Power Syst. Res. **127**, 259–270 (2015). https://doi.org/10.1016/j.epsr.2015.06.012
44. L. Shen, Y. Tang, L.C. Tang, Understanding key factors affecting power systems resilience. Reliab. Eng. Syst. Saf. **212** (2021). https://doi.org/10.1016/j.ress.2021.107621
45. Z. Li, M. Shahidehpour, F. Aminifar, A. Alabdulwahab, Y. Al-Turki, Networked microgrids for enhancing the power system resilience. Proc. IEEE **105**(7), 1289–1310 (2017). https://doi.org/10.1109/JPROC.2017.2685558
46. X. Liu et al., A resilience assessment approach for power system from perspectives of system and component levels. Int. J. Electr. Power Energy Syst. **118** (2020). https://doi.org/10.1016/j.ijepes.2020.105837
47. S. Espinoza, M. Panteli, P. Mancarella, H. Rudnick, Multi-phase assessment and adaptation of power systems resilience to natural hazards. Electr. Power Syst. Res. **136**, 352–361 (2016). https://doi.org/10.1016/j.epsr.2016.03.019
48. D.J. Thompson, W.C.H. Schoonenberg, A.M. Farid, *A Hetero-functional Graph Resilience Analysis of the Future American Electric Power System* (2020). https://doi.org/10.1109/ACCESS.2021.3077856
49. L. Souto et al., Power system resilience to floods: modeling, impact assessment, and mid-term mitigation strategies. Int. J. Electr. Power Energy Syst. **135** (2022). https://doi.org/10.1016/j.ijepes.2021.107545
50. Y. Li, K. Xie, L. Wang, Y. Xiang, Exploiting network topology optimization and demand side management to improve bulk power system resilience under windstorms. Electr. Power Syst. Res. **171**, 127–140 (2019). https://doi.org/10.1016/j.epsr.2019.02.014
51. M. Nazemi, M. Moeini-Aghtaie, M. Fotuhi-Firuzabad, P. Dehghanian, Energy storage planning for enhanced resilience of power distribution networks against earthquakes. IEEE Trans. Sustain. Energy **11**(2), 795–806 (2020). https://doi.org/10.1109/TSTE.2019.2907613
52. K. Lai, Y. Wang, D. Shi, M.S. Illindala, X. Zhang, Z. Wang, A resilient power system operation strategy considering transmission line attacks. IEEE Access **6**, 70633–70643 (2018). https://doi.org/10.1109/ACCESS.2018.2875854
53. G. Huang, J. Wang, C. Chen, J. Qi, C. Guo, Integration of preventive and emergency responses for power grid resilience enhancement. IEEE Trans. Power Syst. **32**(6), 4451–4463 (2017). https://doi.org/10.1109/TPWRS.2017.2685640
54. C. Wang, Y. Hou, F. Qiu, S. Lei, K. Liu, Resilience enhancement with sequentially proactive operation strategies. IEEE Trans. Power Syst. **32**(4), 2847–2857 (2017). https://doi.org/10.1109/TPWRS.2016.2622858

55. Y. Wang, L. Huang, M. Shahidehpour, L.L. Lai, H. Yuan, F.Y. Xu, Resilience-constrained hourly unit commitment in electricity grids. IEEE Trans. Power Syst. **33**(5), 5604–5614 (2018). https://doi.org/10.1109/TPWRS.2018.2817929
56. A.S. Musleh, H.M. Khalid, S.M. Muyeen, A. Al-Durra, A prediction algorithm to enhance grid resilience toward cyber attacks in WAMCS applications. IEEE Syst. J. **13**(1), 710–719 (2019). https://doi.org/10.1109/JSYST.2017.2741483
57. M. Yan et al., Enhancing the transmission grid resilience in ice storms by optimal coordination of power system schedule with pre-positioning and routing of mobile DC de-icing devices. IEEE Trans. Power Syst. **34**(4), 2663–2674 (2019). https://doi.org/10.1109/TPWRS.2019.2899496
58. B. Taheri, A. Safdarian, M. Moeini-Aghtaie, M. Lehtonen, Enhancing resilience level of power distribution systems using proactive operational actions. IEEE Access **7**, 137378–137389 (2019). https://doi.org/10.1109/ACCESS.2019.2941593
59. M. Kamruzzaman, J. Duan, D. Shi, M. Benidris, A deep reinforcement learning-based multi-agent framework to enhance power system resilience using shunt resources. IEEE Trans. Power Syst. (2021). https://doi.org/10.1109/TPWRS.2021.3078446
60. B. Manyena, F. Machingura, P. O'Keefe, Disaster resilience integrated framework for transformation (DRIFT): a new approach to theorising and operationalising resilience. World Dev. **123** (2019). https://doi.org/10.1016/J.WORLDDEV.2019.06.011
61. Government of Malawi, in *SE4ALL Malawi|Action Agenda* (2017)
62. R. Wyss, S. Mühlemeier, C.R. Binder, *An Indicator-Based Approach for Analysing the Resilience of Transitions for Energy Regions. Part II: Empirical Application to the Case of Weiz-Gleisdorf, Austria.* https://doi.org/10.3390/en11092263
63. D. Chattopadhyay, E. Spyrou, N. Mukhi, M. Bazilian, A. Vogt-Schilb, Building climate resilience into power systems plans: Reflections on potential ways forward for Bangladesh. Electr. J. **29**(7), 32–41 (2016). https://doi.org/10.1016/j.tej.2016.08.007
64. G. Harrison, *Climate Adaptation and Resilience in Climate Adaptation and Resilience in Energy Systems gy*
65. V.M. Nik, A.T.D. Perera, D. Chen, Towards climate resilient urban energy systems: a review. Natl. Sci. Rev. **8**(3) (2021). https://doi.org/10.1093/nsr/nwaa134
66. M.V. Martello, A.J. Whittle, J.M. Keenan, F.P. Salvucci, Evaluation of climate change resilience for Boston's rail rapid transit network. Transp. Res. Part D Transp. Environ. **97** (2021). https://doi.org/10.1016/j.trd.2021.102908
67. M. Panteli et al., *Impact of Climate Change on the Resilience of the UK Power System* (2015)
68. L.M. Shakou, J.L. Wybo, G. Reniers, G. Boustras, Developing an innovative framework for enhancing the resilience of critical infrastructure to climate change. Saf. Sci. **118**, 364–378 (2019). https://doi.org/10.1016/j.ssci.2019.05.019
69. N. Kumar, V. Poonia, B.B. Gupta, M.K. Goyal, A novel framework for risk assessment and resilience of critical infrastructure towards climate change. Technol. Forecast. Soc. Change **165** (2021). https://doi.org/10.1016/j.techfore.2020.120532
70. J. Jasiūnas, P.D. Lund, J. Mikkola, Energy system resilience—a review. Renew. Sustain. Energy Rev. **150** (2021). https://doi.org/10.1016/j.rser.2021.111476
71. ESCOM, *Electricity Supply Corporation of Malawi: Presentation on Executive Exchange on Developing an Ancillary Service Market for SAPP*
72. Malawi: energy mix for electricity generation|GlobalPetrolPrices.com. https://www.globalpetrolprices.com/energy_mix.php?countryId=81. Accessed 12 Jul 2022
73. The Ministry of Energy, *The Status of Energy Policy* (2021)
74. The Electricity Supply Corporation of Malawi (ESCOM), in *The Status of Energy Policy* (2022)
75. D. Burillo, M.V. Chester, S. Pincetl, E.D. Fournier, J. Reyna, Forecasting peak electricity demand for Los Angeles considering higher air temperatures due to climate change. Appl. Energy **236**, 1–9 (2019). https://doi.org/10.1016/j.apenergy.2018.11.039
76. K. Handayani, T. Filatova, Y. Krozer, P. Anugrah, Seeking for a climate change mitigation and adaptation nexus: analysis of a long-term power system expansion. Appl. Energy **262**, 114485 (2020). https://doi.org/10.1016/j.apenergy.2019.114485

77. A. Arab, A. Khodaei, R. Eskandarpour, M.P. Thompson, Y. Wei, three lines of defense for wildfire risk management in electric power grids: a review. IEEE Access **9**, 61577–61593 (2021). https://doi.org/10.1109/ACCESS.2021.3074477
78. J. Sieber, Impacts of, and adaptation options to, extreme weather events and climate change concerning thermal power plants. Clim. Change **121**(1), 55–66 (2013). https://doi.org/10.1007/s10584-013-0915-0
79. Y. Fang, Y. Wei, Climate change adaptation on the Qinghai-Tibetan Plateau: the importance of solar energy utilization for rural household. Renew. Sustain. Energy Rev. **18**, 508–518 (2013). https://doi.org/10.1016/j.rser.2012.10.037
80. O.J. Guerra, D.A. Tejada, G.V. Reklaitis, Climate change impacts and adaptation strategies for a hydro-dominated power system via stochastic optimization. Appl. Energy **233–234**, 584–598 (2019). https://doi.org/10.1016/j.apenergy.2018.10.045
81. A. Sapkota, Z. Lu, H. Yang, J. Wang, Role of renewable energy technologies in rural communities' adaptation to climate change in Nepal. Renew. Energy **68**, 793–800 (2014). https://doi.org/10.1016/j.renene.2014.03.003
82. Republic of Zambia, *National Energy Policy*, (2019).
83. S. Mcmanus, E. Seville, D. Brunsdon, J. Vargo, in *Resilience Management: A Framework for Assessing and Improving the Resilience of Organisations* (2007), p. 79 [Online]. Available: http://ir.canterbury.ac.nz/handle/10092/2808
84. D. Stockemer, *Quantitative Methods for the Social Sciences*. (2019). https://doi.org/10.1007/978-3-319-99118-4
85. T. Makinde, "Problems of Policy Implementation in Developing Nations: The Nigerian Experience," *Kamla Raj Enterprises*, **11**(1), 63–69 (2017). https://doi.org/10.1080/09718923.2005.11892495
86. Policy implementation. https://journals.co.za/doi/epdf/10.10520/ejc-adminpub-v17-n4-a2 (accessed Jan. 22, 2023).
87. D. Millard, "The Role and Importance of Energy Statistics," 2015.
88. T. D. Lujanskaya, "Energy Statistics: Importance, Challenges, Needs," 2013. Accessed: Jan. 22, 2023. [Online]. Available: http://www.inogate.org/documents/Session%206.1_Moldovan%20experience_AEER%20Energy%20Statistics_ENG.pdf