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GEAPP

Radical Collaboration for Capacity Building in Power Sector Integrated Resource Planning Driving M300 for Low- and Middle- Income Countries

The case of Malawi



Ministry of Energy and stakeholders attending a demand forecast training workshop



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Summary

The 2022 Integrated Resource Planning (IRP) update for Malawi's power sector represents a significant collaborative effort aimed at revising and enhancing the country's electricity generation, transmission, and distribution master plans over a 20-year horizon, while providing on-job training to locals in the IRP development. This project was led by ECA Associates and Tractebel Engie as consultants for demand forecast and masterplans (generation, transmission & distribution) respectively, co-designed by the Ministry of Energy and the Global Energy Alliance for People and Planet (GEAPP), and financed by GEAPP. Key stakeholders involved in the Malawi's IRP included from the Ministry of Energy itself, Electricity Supply Corporation of Malawi (ESCOM), Malawi Energy Regulatory Authority (MERA), Electricity Generation Company (EGENCO), academic institutions, and development partners including the World Bank, USAID-Power Africa and the European delegation in Malawi.

The primary objectives were twofold: first, to improve the accuracy and relevance of the IRP by incorporating the latest data and sector insights; second, to facilitate skills transfer to local stakeholders to build sustainable capacity in power system planning. To achieve these goals, the project made use of regular Working Group meetings and a comprehensive set of capacity building sessions covering GIS modeling, generation expansion using Plexos, transmission expansion planning using DlgSILENT, and distribution planning using DlgSILENT.

For the sector's sustainable capacity building, the project included a Training of Trainers (ToT) program designed to empower selected participants from the power sector institutions to independently train others using materials developed during the project. This approach ensured a long-term sustainability of the knowledge and skills acquired, fostering ongoing capacity development within Malawi's energy sector.

The updated IRP reflects recent data and developments to maintain a least-cost pathway for electricity supply in Malawi. It includes four key studies: demand forecasting with loss reduction and energy efficiency strategies; generation development planning focusing on hydro expansion, integration of renewables, and regional interconnections; transmission development planning outlining infrastructure upgrades and reinforcements to support growing demand and new generation projects; and distribution network planning emphasizing GIS-based load analysis, rural electrification, and urban network constraints.

This paper provides a structured overview of the project activities, focusing on capacity building efforts, stakeholder engagement, involvement of local subcontractors, and reflections on the overall impact and outcomes.

1. Introduction

1.1 Background

By 2022, Malawi's IRP developed in 2017 lost relevance as key assumptions driving the power sector development had changed over time. The Malawi Government through the Ministry of Energy engaged GEAPP for a partnership to support an update the 2017 IRP.

The 2017 IRP had an electricity demand forecast, a generation expansion plan, and a transmission expansion plan. In the Malawi's 2022 IRP update, stakeholders added a distribution network expansion plan as a roadmap to guarantee offtake of power to critical demand centers whilst ensuring alignment with the country's ambition for universal access to energy and economic growth through agriculture, tourism, mining, and manufacturing.



1.2 Procurement of Leading Consultants

The process to select lead consultants for the assignments began with GEAPP drafting Terms of Reference (TORs) for updating the 2017 Malawi IRP. The TORs were shared among electricity sector stakeholders in Malawi including the Ministry of Energy, development partners and utilities for validation (and ownership). Upon incorporating comments from the stakeholders, the TORs were included in a request for proposal for the works.

To reduce procurement lead time, the tender was restricted to a list of consultants recommended by GEAPP and the Power Sector Institutions of Malawi based on their knowledge of consultants with previous experience in carrying out related assignments in Malawi, Africa and other regions of similar contexts. The final list was shared with the power sector stakeholders including the Ministry of Energy for vetting to avoid inviting responses to the RFP from firms with a poor relationship with the Government of Malawi. For the demand forecast, 13 firms received the RFP and 6 responded whilst the masterplans assignment had 25 firms that received RFP out of which 6 responded in time. In the entire process, GEAPP played a secretariat role: sent the RFP to the targeted firms; coordinated responses to clarifications, received the bids, developed evaluation templates, coordinated evaluation meetings which were chaired by the Ministry of Energy. The evaluation team comprised representatives from the Ministry of Energy, MERA, ESCOM, Power Market Limited (former Single Buyer), EGENCO and GEAPP.

2. Technical Approach

2.1 Components and Steps of the IRP Update

The IRP update was organized into multiple workstreams addressing each segment of the power system, namely: demand forecast, generation, transmission, and distribution focusing on avoiding offtake bottlenecks and ensuring financial viability and operational efficiency (Figure 1).

Integrated Energy Plan (IEP) database and Malawi Rural Electrification Program (MAREP) Masterplan Study:

Between 2021 and 2022, with support of GEAPP in partnership with SEforALL, Malawi had also developed a geospatial-based IEP for determining the least cost approach (grid, solar home systems, or minigrid) for electrifying locations. The Ministry of Energy had also developed a masterplan that identified rural load centres to be electrified by 2030 through MAREP. The distribution expansion plan under the IRP update integrated the IEP and MAREP preferential areas for grid electrification.

Demand forecast. This includes three scenarios reflecting varying economic growth and electrification rates. The base case projects an average annual demand growth of 8% based on past trajectory, while a high-case scenario projects universal electrification by 2030. The demand forecast was a key input that informed the development of integrated master plans for generation, transmission, and distribution, ensuring alignment to reliably meet the Mission 300 demand targets across all segments of the power system.

Generation expansion plan: The plan incorporates stochastic modeling of hydrology to manage resource variability as hydro power is expanded complemented by solar PV, wind, biomass and gas plants. The generation plan prioritizes refurbishment of hydropower plants over new diesel capacity, integrates battery energy storage systems, provides for regional interconnection and recommends demand-side management measures. Strategic projects and scenarios with large hydro are considered to ensure reliability, affordability, and sustainability while aligning with national policies and regional power pool integration.

Transmission expansion plan: Transmission upgrades focus on replacing 66kV lines with 132kV and integrating regional interconnectors to Mozambique, Zambia, and Tanzania, enhancing system stability and reducing losses.

Distribution expansion plan: With the demand forecast study, the IEP database, and the MAREP masterplan as key inputs, the distribution masterplan targets rural electrification and urban load growth, recommending network reinforcements, new substations, and technical loss reductions, which are all pivotal to mission 300.

The IRP stresses continuous monitoring, capacity building, and periodic updates every five years to adapt to evolving conditions and ensure effective implementation.

2.2 Working Groups

Key to the success of developing Malawi's 2022 IRP was the establishment of three Working Groups (WGs) to facilitate regular discussion and interaction between subject matter experts on the different topics. There were four domain-specific WGs, each comprising a group of

experts from the Ministry of Energy, ESCOM, MERA, EGENCO and academic institutions, viz:

1. WG 1: Demand Forecast
2. WG 2: Generation planning & dispatch diagnosis
3. WG 3: Power system analysis
4. WG 4: Distribution planning

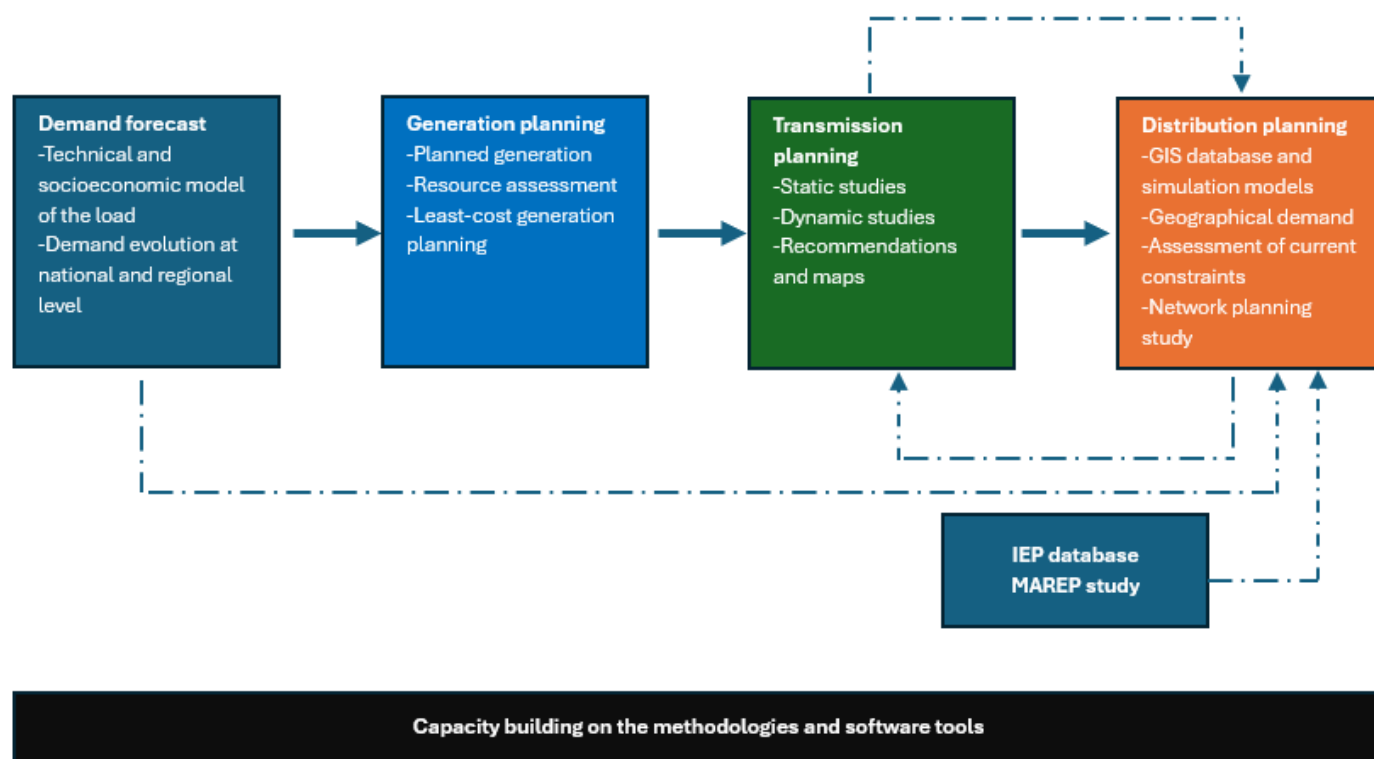


Figure 1 Workstreams of Malawi's 2022 IRP update

The WGs provided a platform for the experts to exchange ideas and learn from the lead consultants on the modelling assumptions, methodologies applied, the ways of working, the interpretation of results, while incorporating local contexts. The WG exchanges ensured:

- Data availability and guidance of where to find key information for the assignment
- Local and continuous validation of main assumptions, data, and methodologies used in the modelling

- Full understanding of the works and therefore local ownership of the methodologies and results applied/produced
- Knowledge transfer among the stakeholders to build sustainable capacity in power system planning and ensure Malawi's energy sector has local expertise to support future updates of the IRP. The involvement of the academia was key to initiating a discussion around integrating industry practice on IRPs to university curricula on power system planning for long-term sustainability of the knowledge and skills acquired

Throughout the process, WG meetings played a vital role serving as a platform for active stakeholder engagement, garnering contributions from experts about their sector knowledge, shared institutional priorities, and initial views on each WG preliminary results. The WG meetings also fostered cross-institutional collaboration, allowing stakeholders to identify gaps, raise concerns, and suggest improvements grounded in operational realities which lead consultants could not be privy to. This inclusive process

ensured the master plan reflected practical challenges and aligned with national development goals. Further, coordinated planning of the three WGs ensured that as generation and transmission systems expanded, the distribution network would be adequately reinforced handle increased loads, resulting in a more efficient, reliable, and sustainable power system



2.3 Stakeholder validation

The lead consultants submitted draft reports to the Ministry of Energy which organized validation meetings involving key stakeholders to review the reports, first

being the demand forecast, energy efficiency and loss reduction plan, and secondly, the masterplans— generation, transmission and distribution expansion plans, in that order. Stakeholders and experts were given a period of one-to-two weeks to thoroughly review the

reports after which the Ministry collated feedback and shared the same with the consultants.

2.4 Capacity Building Sessions

There were six major training modules conducted over two-week periods each for the four WGs. These sessions targeted different aspects of power system planning and equipped participants and members of the WGs with both theoretical knowledge and practical skills. Noting that ESCOM and MERA already had access to PLEXOS and DlgSILENT Power Factory licenses, GEAPP procured similar license versions for the Ministry of Energy and academic institutions to facilitate practical application and mastery of skills during the training workshops.

2.4.1 Training 1: Framework for Load Forecasting (Oct 2022)

The main objective of this training was to provide a fundamental framework for load forecasting to enable stakeholders understand and make informed decisions regarding the approach and assumptions to be employed in the update of the 2017 load forecast. The training workshops covered:

- IRPs and the relationship with demand forecasting
- Load forecasting techniques for IRP
- Developing demand forecast models in MS Excel
- Input assumptions and scenarios for updating the Malawi IRP demand forecast

2.4.2 Training 2: Demand Forecast, Demand Side

Management (DSM) and Energy Efficiency (EE) measures and Loss reduction plan for Malawi's IRP (Apr 2023) This training took participants through a complete demand forecasting model embedding suppressed demand, DSM, EE, and loss reduction measures to complete a demand forecast. The training had five sessions, viz:

- Demand forecasting and DSM, an important element of an IRP

- Assessment of DSM options for the Malawi IRP model
- Demand forecast approach for Malawi and loss reduction plan
- Data requirements for demand forecasting and DSM analysis
- Navigating the final national demand forecast model in MS Excel

2.4.3 Training 3: GIS Modelling and Power System Planning (May 2023)

The training introduced foundational concepts in power system planning, load forecasting, and Geographic Information Systems (GIS) using QGIS software. It consisted of three modules:

- Long-term planning principles
- Load forecasting methods
- GIS and QGIS practical exercises

2.4.4 Training 4: Generation Expansion Planning Using PLEXOS (November 2023)

This training comprised four modules focused on generation planning and the use of PLEXOS software:

- Generation planning fundamentals
- Presentation of draft Generation Master Plan
- PLEXOS basic features
- PLEXOS advanced features

2.4.5 Training 5: Transmission Expansion Planning Using DlgSILENT Power Factory (June 2024)

Focused on transmission planning, this training had four modules:

- Draft Transmission Master Plan presentation; data, approach and results
- Static module training
- Dynamic module training

- Hands-on exercises

2.4.6 Training 6: Distribution Planning Using DlgSILENT and QGIS (June 2024)

The final training addressed distribution planning through four modules:

- Distribution master plan presentation; data, approach and results
- QGIS refresher
- DlgSILENT for distribution networks
- Integrated planning exercises

2.5 Evaluation of Knowledge Transfer

The consultants applied individual and group exercises, and interactive discussions for assessment of participants learning. The assessments and pre-and post- training evaluations undertaken by the consultants showed that the participants grasped the subject matter well.

Feedback was also collected after each training session and the participants appreciated the comprehensive coverage of topics, balancing theory with practical applications such as demand forecast modelling techniques, power system modeling, load flow calculations, and advanced simulations. The interactive format encouraged questions and dialogue, reinforcing learning and instilling confidence. Another critical success factor to the capacity building program was the openness of the trainers and willingness to transfer skills to the finest detail. Key recommendations for improvement included a need for refresher and advanced courses to ensure mastery of course material.

Although GEAPP had supported the Ministry of Energy and academic institutions with licenses for Plexos and DlgSILENT, there were still challenges of limited software access by other participants due to device compatibility issues, which constrained some of their ability to fully engage during practical components. Suggestions emphasized increasing software availability, acquiring the right devices and dedicating more time to applied learning to enhance effectiveness.

2.6 Training of Trainers (ToT) Program

To ensure the sustainability of knowledge transfer beyond the project's conclusion, a Training of Trainers (ToT) program was set up, one for the demand forecast session and another one for the IRP generation, transmission and distribution masterplans. Selected participants who demonstrated strong understanding during earlier sessions were provided with comprehensive training materials—including presentations, models, and practical tools—to enable

them to independently train others. Essentially, the ToT trainers were equipped to disseminate the project's methodologies and findings, covering national demand forecast for IRP and advanced planning tools such as PLEXOS, QGIS, DlgSILENT, and the custom GIS import tool developed for DlgSILENT. To put theory into practice, GEAPP organized an energy stakeholders training workshop where the trainers facilitated a number of sessions on IRP. This approach fostered sustainability of capacity building, strengthening sector-wide communication, and supporting adaptive learning and management of Malawi's energy master plan.

The project also culminated into an online webinar attended by over 30 participants, including representatives from external organizations like the University of Cambridge, Africa Practice, and the Clean Cooking Initiative. The webinar featured co-presentations by the lead consultants, local subcontractors, and ToT participants, followed by a Q&A session that allowed attendees to clarify integrated planning topics and discuss implementation considerations.

3. Engagement of Local Subcontractors

Local subcontractors were integral to the project, supporting with data collection, engagement with local stakeholders, sharing the local context on matters of interest and sharing insights on environmental and social impact assessments of the integrated master plan. Their work ensured that the plan was aligned with local community needs and adhered to sustainable development principles. They also acted as

intermediaries between the consultants and local stakeholders, facilitating data collection and improving information flow. This collaboration enriched the project with valuable contextual insights and strengthened local technical capacity through exposure to international methodologies. Their participation in the closing webinar further demonstrated their enhanced expertise and integration into the project team, positioning them well for future contributions to Malawi's energy sector development.

4.Outcomes of Malawi's 2022 IRP Update

The 2022 IRP update has been key to activating the development of the Malawi Energy Compact under the M300 led by the World Bank and the African Development Bank supported by GEAPP, SEforALL and the Rockefeller Foundation. In addition, the outputs of the updated Malawi's 2022 IRP helped to shape the ASCENT projects under the \$250M World Bank grant signed at the Africa Energy Summit in Dar es Salaam.

5.Conclusion

Malawi's 2022 IRP supported by GEAPP is an exemplar of deliberate radical collaboration for power sector planning leading to a comprehensive, integrated master plan harmonizing demand forecast, generation, transmission, and distribution planning within a cohesive framework. The consultative procurement processes ensured that the consultants engaged were accepted and met the expectations of all key stakeholders. The capacity building sessions empowered key stakeholders—including government (Ministry of Energy) officials, utility staff, regulators, and academicians—with essential knowledge and skills in advanced planning tools and methodologies. Active stakeholder engagement through working groups ensured the plan was firmly rooted in sector realities and aligned with national objectives. The involvement of local subcontractors added critical environmental, social, and contextual perspectives, enhancing the plan's relevance and sustainability.

The Training of Trainers program guaranteed continued knowledge dissemination, fostering sustainable capacity growth and collaborative dialogue within the sector. Overall, the project has significantly improved coordination, communication, and technical expertise, laying a solid foundation for effective and sustainable implementation of Malawi's energy master plans over the coming decades.

6.Call to Action

- IRP development process from development of ToRs, procurement of consultants to drafting reports requires alliancing and continued commitment from all stakeholders including government agencies, utilities, regulators, academic institutions, and local partners.
- There is need to maintain active engagement between local experts from stakeholder institutions and consultants for on-the job training and continuous interaction or discussions before the final products are developed.
- Structuring of IRP consultancy assignments should include capacity building and engagement of local experts and the academia to realize sustainable regular updates of IRPs without or with minimal support of external consultants.
- ToT programs for those trained are key to ensuring mastery and application of skills learnt.
- Financiers of IRPs should consider supporting access to relevant power planning and modelling software for practical appreciation of the IRP process.

