Sabah's Rural Electrification Policy Landscape

A summary of Sabah's rural and renewable energy regulatory and enabling environment, and an investigation into the ways in which it can be improved to enhance and scale mini-grids for rural electrification.

Overview

Sabah, as a state, has demonstrated a commitment to meeting the energy needs of its considerably large number of rural communities, in spite of the logistical and financial challenges of doing so among such a distributed population. A wide array of departments across the public sector, including the Ministry of Rural Development, the Ministry of Education, and the Public Works Department, among others, have sought to do this through, at least in part, renewable and distributed technologies. However, there are also considerable opportunities to improve on, optimise, and clarify the regulatory environment around the delivery of energy resources, particularly mini-grids, to rural populations. This document first describes the current rural electrification and policy landscape in Sabah, drawing a historical timeline from Sabah's (Malaysia's) early rural and renewable energy policies to their current form. The hope here is that other energy sector stakeholders, including the private sector, civil society, and perhaps even other public sector actors, can better understand how the existing policy landscape may support, or limit, plans to address Sabah's rural electrification needs. Secondly, this document provides recommendations, drawn from Sabah's own energy actors, literature and documented experience on successful rural electrification programmes internationally, to accelerate and optimise the delivery of sustainable rural electrification. Some of the key recommendations include the following:

- There is an urgent need to **prioritise and address rural electrification** and energy poverty in over 400 villages in Sabah by **formulating a well-designed, integrated and coordinated rural electrification roadmap** that **prioritises renewable energy mini-grids** as a primary strategy.
- **Renewable energy mini-grids have significant potential** to deliver cost-effective electrification and socio-economic benefits for rural populations.
- However, **scaling up mini-grids will require further financial investment** and a delivery programme that **leverages innovative business and delivery models** through an **evidence-based, multi-stakeholder approach**.
- A **mini-grid quality assurance framework would also help ensure that safety and standards are met**, within existing rules and regulations around rural electrification.

Sabah At A Glance

- With an area of 73,631 km^2 and a population of 3.9 million[1], Sabah is Malaysia's second largest state [1], [2] and has a rural population of 38.8% [2]. Sabah also has the country's highest poverty rate, with a 25.3% incidence of absolute poverty in 2020 [3].
- In 2020, Sabah's economy was dominated by the services sector (47.1%), followed by mining and quarrying (which includes oil and gas extraction) at 25.4%, and agriculture (which includes palm oil, forestry and logging) at 16.5% [4].
- Sabah's physical geography is a mix of coastal areas, mountainous ranges and tropical rainforests, and is home to a portion of the second oldest rainforest in the world.
- Due to Sabah's diverse and challenging geography and terrain, and with over a quarter of its population dispersely located in rural and remote areas, infrastructure development

[1] As of 2020.

and delivery has been difficult. Development and investment in connective and basic infrastructure and services are lacking in Sabah, especially when compared to Peninsular Malaysia.

Current Energy Landscape

- Malaysia has a total installed electricity capacity of 33.99 GW[2], with the majority of its capacity coming from natural gas (43.7%), coal (31.4%) and hydro (18.1%) [5]. The remaining installed capacity comes from diesel, biomass, solar, and bioenergy (all between 0.2-2.4%).
- With a total installed capacity of 1,919 MW, Sabah's capacity mix consists of natural gas at 64.3%, followed by diesel at 15.1%, biomass (8.7%), solar (5.8%) and hydro (4.6%). Biogas and other sources are at 1% or under [5].
- Sabah's available capacity is 1,277 MW[2], with a peak demand of 955 MW, and a reserve margin of 33.7%. Electricity consumption is largely from the commercial sector (42.2%), followed by residential and industry sectors at 32.9% and 24.9% respectively [5].
- Electricity is heavily subsidised by the government, and the average generation cost per unit of generation is 23.3 sen/kWh [6].
- While the renewable energy share in Sabah's installed capacity mix is over 20%, only 11.4% of the gross electricity generated in 2018 was from renewable energy sources [5]. Not unlike in the rest of the country, renewable energy uptake has been slow, due to long-term fuel supply commitments [7], limited access to financing, and a priority on expansion of the existing grid over integration of renewables. Malaysia has a renewable energy capacity mix target of 31% by 2025 (and 40% by 2035) [8], with a strategy to focus on large hydro, solar, and increasing biomass and biogas. Green mechanisms to encourage investment, uptake and increased consumer options will include a Green Tariff and Renewable Energy Certificates (RECs), especially for corporates.
- Although Sabah's available capacity is currently sufficient to meet peak demand, due to an ageing grid and network, electricity service reliability can be improved. Reliability indicators such as SAIDI and SAIFI[3] for the state in 2019 was 205.31 minutes/customer/year, and 10.83 interruptions/customer/year respectively, which are significantly higher than Peninsular Malaysia's SAIDI and SAIFI at 48.13 minutes/customer/year and 0.83 interruptions/customer/year [9].
- Sabah's state electricity utility Sabah Electricity Sdn. Bhd. (SESB) is owned by the multinational electric company Tenaga Nasional Berhad (TNB), which operates in Peninsular Malaysia. In 2018, the then federal-level Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) announced the transfer of SESB's ownership back to the Sabah State Government. The handover (originally expected to be completed in 2021) has not yet taken place [6].
- Recent political volatility has affected Sabah's energy-related plans and goals. Previous plans, not yet fully realised, to improve system supply and reliability, increase renewable energy (RE) penetration while increasing rural electrification, have been reintroduced and highlighted in the 12th Malaysia Plan (RMK 12), with a restatement of a rural

[2] As of 2018.
[3] System Average Interruption Duration Index (SAIDI) describes the total duration of the average customer's interruption. System Average Interruption Frequency Index (SAIFI) describes the frequency at which the average customer experiences an interruption.

electrification target from 2015 of 99%. According to the RMK 12, distributed renewable energy systems will be an alternative to grid extension in rural areas. Additionally, while the previous government recognised and acknowledged the need to develop and implement new regulatory frameworks for mini-grid delivery, this has not yet been highlighted and featured in the current government's energy agenda.

- Government data and statistics state that Sabah has an electrification rate of between 98-99.7%, with the majority of the unelectrified located in rural areas [2], [10]. However, unofficial sources of data quote state electrification rates of between 77-89% [11], [12]. With a rural population of almost 40%, many living in remote and geographically challenging areas to access, the reality is most likely somewhere in between.

Rural Electrification in Sabah

Rural[4] electrification in Sabah falls under the purview of the federal-level Ministry of Rural Development or *Kementerian Pembangunan Luar Bandar* (KPLB). KPLB delivers rural electrification through its Rural Electrification or *Bekalan Elektrik Luar Bandar* (BELB) programme, which began in 2010 and aims to provide 24-hour electricity access[5] to unelectrified communities. Efforts in Sabah can be broken down into the following initiatives:

[4] Rural areas in Malaysia are defined as areas other than urban areas, with settlements of less than 10,000 in population, with agricultural characteristics and rich in natural resources (PLANMalaysia (department of Town and Country Planning) 2011).

[5] A more descriptive definition of electricity access that describes the level of service provided (i.e. length and quality of supply) does not currently exist or is not publicly available.

Rural Electrification Strategy	**Description**	**Selection Criteria**	**Estimated Costs**	**Main Issues and Challenges**
1. Grid extension (BELB)	This is the Ministry's main rural electrification strategy. Over 80% of rural electrification funds has been spent on grid extension to rural areas [7].	As long as average costs per household-connection are under RM100,000 [13], grid expansion is first used to electrify rural areas, with consideration given to highly populated areas with existing community institutions and infrastructure. When grid extension costs exceed RM100,000, off-grid and distributed systems are deployed instead.	< RM100,000 per household connection	Not cost–effective for rural populations who are expensive to reach due to challenging terrain and a lack of connective infrastructure, and have limited ability to pay.
2. Off-grid mini-grids (BELB)	Between Tier 3-4[6] electricity supply. Decentralised or distributed generation systems such as mini-grids. The first solar systems used for rural electrification were installed in the late 1990's. In the early 2000's, rural electrification efforts shifted to East Malaysia, and an electricity supply trust fund (i.e. the *Amanah Akaun Industri Bekalan*	No plans for grid extension within 10-15 years. Communities with at least 20 households, preferably clustered, are prioritised.	Past BELB solar hybrid projects have cost between RM15,000 - 50,000 per household connection (for 20 - 100 households)[8] [7]. However, reports from SESB describe costs for solar hybrid systems in Sabah reaching	• Top-down approach to mini-grid project development. Funding and tenders are issued by federal KPLB, with some management of project implementation by KPLBS. • Slow deployment (as mini-grids are not a main strategy)

[6] According to the World Bank's Multi-Tier Framework (MTF), a framework for measuring energy access. See here for more info. BELB mini-grids aim to supply an average capacity of 700-1,000W per household and a daily energy capacity of 2kWh.
[8] Additional costs for logistics and transportation (other than water and land) are not included in these estimates.

	Elektrik or AAIBE[7]) was established to support financing [7]. Selection of mini-grid technology in these rural areas would depend on remoteness of the location, availability of renewable energy resources and access to connective infrastructure. Systems are handed over to local utilities TNB (in Peninsular Malaysia) and SESB (in Sabah) for continued operations and maintenance. Mini-grids have also been installed by the Ministry of Education for rural schools, as well as by the Ministry of Health for rural clinics (mostly non-renewable systems).		RM150,000 per household connection.	• Focus is on delivery of technology and electricity connections. Project tenders do not focus on including socio-economic opportunity and productive end use needs. This also increases the costs of these systems as they do not leverage more integrated and innovative business models. • High entry barrier for project developers. Project tenders require companies to show high net worth and cash flow. More community-focused developers and energy practitioners tend to be smaller companies and organisations who are unable to meet financial requirements of project tenders. This limits the number of developers with the appropriate experience in rural mini-grids.
3. Solar home systems	Individual solar home systems for extremely remote communities.	Extremely remote (definition not publicly available) communities.	N/A. Based on global data, good quality solar	Limited Tier 2-3 energy provided, which also limits productive use

[7] AAIBE was formed and launched in July 1997 to support rural electrification, research and development of renewable energy, energy efficiency and human resource development for the power sector. Independent power producers (IPP) or electricity supply licensees contribute 1% of their total annual income from electricity sales to the fund.

(BELB)			home systems cost around USD200-400 [14].	opportunities.
4. Distributed renewable energy systems (BELBA[9]), delivered by KPLBS	Mini-grids and other distributed systems from renewable energy generation. Recently launched and delivered by Sabah's state Ministry of Rural Development or KPLBS.	BELBA will focus on KPLBS-registered communities through its MESEJ and Kampung Sejahtera programmes.	N/A	This programme is new, and may operate similar to BELB, but with more state-level decision-making.
5. Community-based/involved Mini-grids (Private/civil society initiatives)	Oftentimes grant-based community-based systems supplying Tier 3-5 electricity.	Remote communities that have not been served by BELB.	RM30,000 - 65,000 per household[10] (based on technology, location)	• Limited funding and resources. Project design and implementation is heavily influenced by funding availability. • Limited capacity of energy practitioners to scale up the number of projects. • Installed systems may not follow sufficient safety and reliability standards as there are no clear guidelines and standards for off-grid, community-based systems.

Table 1. Existing rural electrification initiatives in Sabah

[9] Alternative Rural Electrification or *Bekalan Elektrik Luar Bandar*, a programme launched in 2020 by KPLBS (Sabah's state Ministry of Rural Development).

[10] For systems between 5-30kW systems, average 1kW peak per household. Mostly micro-hydro, with some solar.

As can be seen from the above table, the government's main rural electrification strategy thus far has been grid extension. This has been relatively successful in Peninsular Malaysia, where there is greater investment in infrastructure and connectivity. However in Sabah, with its large rural and remote population and mountainous terrain, grid extension is extremely costly and challenging to deploy.

In addition to the BELB, in 2020, Sabah launched the Rural Alternative Electrification Supply Programme or *Bekalan Elektrik Luar Bandar Alternatif* (BELBA), which focuses on using distributed renewable energy systems for rural electrification [15]. The BELBA will focus on KPLBS-registered communities, as part of its MESEJ and Kampung Sejahtera programmes[11].

Outside of government efforts such as the BELB/BELBA (as described in Table 1. Existing rural electrification efforts in Sabah), there have been approximately over 40 community-based renewable energy mini-grid systems[12] implemented in Sabah over the last few decades. These are usually either grant-based systems or funded through public donations and installed by civil society or community-based, nonprofit organisations. Projects and systems are typically scoped to fit funding availability and limited resources, but are designed to provide above Tier 3 electricity access. These systems are also collaboratively developed and implemented with communities and benefit from a high degree of community involvement and engagement, which helps to reduce installation, operational and maintenance costs especially when community members are trained to operate and manage their systems. Examples of these systems have been documented in multiple studies [16]–[19] and show that mini-grid sustainability and socio-economic benefits are significantly increased when there is a high level of community engagement and involvement, and when systems are developed to meet community needs and expectations. As these systems are generally small in size (between 5 - 30 kW per community) and are community-based, they are viewed as community or privately-owned for self-generation and are typically not licensed or have official governmental approval.

Electricity supply and generation in Malaysia is governed by The Electricity Supply Act 1990 (Act 445) [20], [21], [22] and enforced by the Energy Commission or *Suruhanjaya Tenaga* (ST). The Act includes licensing and requires any activity related to supplying electricity to be licensed. Some key highlights from the Act, relevant for distributed renewable energy systems for rural electrification:

- Licences are not required for self generation and consumption systems under 5 kW[13]
- Three-phase solar systems up to 72 kW, or single phase solar systems up to 24 kW, are exempted from licensing

[11] Kampung Sejahtera is a KPLBS programme that focuses on socio-economic development of the poorest and/or most remote villages in Sabah, while MESEJ focuses on communities located in agricultural estates.
[12] These are mostly micro-hydro systems, which have a lower range of costs, e.g. Levelised Cost of Energy (LCOE)'s of approximately USD 0.05-0.30 per kWh compared to solar mini-grids at USD 0.40-1.00 per kWh (Vaghela 2019).
[13] Via an exemption.

- For public installations and private installations[14] above 5 MW, licence applications are submitted to ST's main (federal-level) office, while for private installations under 5 MW, licence applications are submitted to ST's regional offices or at state level
- A supply licence for public installation is generally meant to cover an agreement with a legal PPA between a power producer and a single consumer (or a residential complex)
- ST has the authority to deem what is fit and appropriate for public installation
- Requirements for licence application:
  - Prior to installation - Company registration documents, site location and plan, project financial documents, approval letters from relevant local authorities (i.e. SESB, state-level agencies), overall project proposal.
  - Upon commissioning - Appropriate form to ST and registered competent person. Recommended to submit at least 3 months before operation date. Provisional licences are also granted for those who need them for project financing/development purposes
- Licence fees for renewable energy systems under 5 MW are charged on an annual basis at RM1.65 per kW, minimum fees are RM100 and capped at RM2,200, including a processing fee of RM100.

In addition, current code and regulations around distribution and interconnection of off-grid systems for rural electrification code are also enforced by ST and detailed in the Distribution Code for Peninsular Malaysia, Sabah and F. T. Labuan (Amendments) 2017 under the Electricity Supply Act 1990 (Act 445) [20] and Renewable Energy Act 2011 (Act 725). Key points from the Distribution Codes relevant for rural electrification are listed below:

- Rural Distribution Systems are defined as Medium Voltage (MV) systems with a feeder length of over 30 km from original supply source, with sections supplied at Low Voltage (LV).
- Security level for said systems can be 'Medium', defined as a target restoration time of not more than 24 hours, but with an exception given to 'locations with challenging access'.
- Systems under 5 MW are required to comply with the Malaysian Distribution Code (MDC). Any Distributed Generator (DG) with a net output of less than 5 MW is required to comply with MDC, and is not subject to Central Dispatch under the Grid System Operator (GSO).
- Guidance on planning and design of DGs can be found in the Sustainable Energy Development Authority (SEDA)'s "Technical and Operational Requirement - Renewable Energy Act 2011", and TNB's "Technical Guidebook for the Connection of Generation to the Distribution System" and "Technical Guidebook on Grid Interconnection of Photovoltaic Power Generation System to LV and MV Network".
- Standards and code for distribution, operation, maintenance, equipment and meters are listed for different voltages.

[14] Public installations are installations that supply electricity to anyone else other than the licensee, while private installations are defined as electricity supplied to only the licensee on his/her own premises. Public installations also include supplying electricity and 'other services' to users in a complex, multi-storey building, or 'specific areas' presumably nearby. ST

Key points from the Technical and Operational Requirement - Renewable Energy Act 2011 [23] :

- LV[15] renewable energy installations in Sabah and Labuan are defined as installations with a net export capacity[16] of up to and including 72 kW/rated kWp.
- For systems above 72 kWp, the power producer requires an application to SEDA for feed-in approval, and a written request to the distribution licensee (who owns the distribution network). A Renewable Energy Power Purchase (REPP) agreement between the power producer and distribution licensee needs to be made to establish a connection.
- The nominal voltage level at connection point is 230V for systems up to and including 10 kW(p). A nominal voltage of 400 V is required for systems above 10 kW(p) and up to and including 425 kW(p).

The Renewable Energy Act 2011 includes requirements from Electricity Supply Act 1990, requirements issued by ST, and the International Electrotechnical Commission standards.

The Grid Code for Sabah and Labuan (Amendments) 2017 covers further regulation around electricity supply from or connected to the main grid and is relevant to rural mini-grids that aim to eventually connect to the main grid. The Grid Code also includes a Planning Code, which is meant to include detailed plans for rural electrification in Sabah, using programmes set by KPLB. The Planning Code also lists SESB as responsible for electrifying communities not being served by the grid, by developing a Rural Electrification Plan in accordance with KPLB's targets [24]. .

The current laws, rules, regulations and codes do not sufficiently cover nor detail available licensing, levels of service, or safety and operational standards for small, community-scale renewable energy systems under 72 kW. There are also currently no clear guidelines for private distributed energy systems or rural electrification initiatives outside of BELB to seek governmental approval and licensing. This leaves private project delivery vulnerable to state and/or federal politics. Project developers attempting to gain the relevant permits and licensing to install systems often run into difficulties obtaining approvals from government departments not set up to evaluate and grant approvals outside of BELB's streamlined process and workflow. To avoid issues, community-based systems are sometimes carefully designed and planned around existing regulations.

In contrast, the BELB programme employs a straightforward tendering process, whereby permits and licensing are managed by the state departments involved. Project developers responding to tenders are required to construct and follow regulations, but have less groundwork to do for approvals. Project delivery is monitored by the Public Works Department or *Jabatan Kerja Raya* (JKR), or sometimes outsourced to the local utility. Warranty and Operations and Maintenance (O&M) requirements for BELB projects have thus far been limited and oftentimes insufficient, resulting in poor handover, a lack of post-installation services, and a gap in data collection and monitoring for ongoing O&M [25]. BELB systems are also designed without substantive input from communities and do not completely address communities' various energy priorities and needs. When electricity services do not meet community priorities, rural users and communities are unable to fully realise the socio-economic benefits of electrification.

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[15] Between 50 V to 1,000 V.

[16] Defined as the maximum amount of electrical power that can be connected or delivered to an electricity distribution network at the connection point.

There is also a lack of clarity on what constitutes a public installation and the sale of energy services when it comes to community mini-grids. The existing regulations and processes have been set up to cover supply and sale of electricity to the grid's single owner (i.e. selling as IPPs to the main utility), or to develop and set up renewable energy systems and sell power to a single user, aimed at scaling urban residential and commercial solar systems (hence the exemption for solar systems up to 72 kW). The rules and regulations do not expressly prohibit the sale of electricity as long as the appropriate licensing is obtained. However in practice licensing requirements are unclear when it comes to community-scale mini-grids, and regulatory approvals do not include mini-grids, especially renewable and off-grid systems for rural electrification. This limits private investment and financing into off-grid mini-grids, preventing business models that include the sale of electricity services via mini-grids.

Between the years 2010 to 2017, as many as 699 rural villages were electrified via grid extension under the BELB programme, while 23 villages received solar mini-grids through BELB in 2017 [26]. Since then, more solar systems have been deployed and there are currently 35 solar (hybrid) mini-grids operating, with 17 more to be completed soon [10]. SESB estimates there are approximately 378 villages still without electricity access in Sabah today, and plans to achieve 99.9% access by 2025 through grid extension (318 villages) and distributed systems (60 villages) [10]. However, other sources[17] estimate that there are over 400 villages in Sabah still without electricity access, with data discrepancies due to differing definitions and data collection methods[18].

[17] i.e. Based on preliminary studies from the Sabah Renewable Energy Rural Electrification Roadmap consortium.
[18] e.g. The definition of what constitutes a village.

Current Policy Landscape

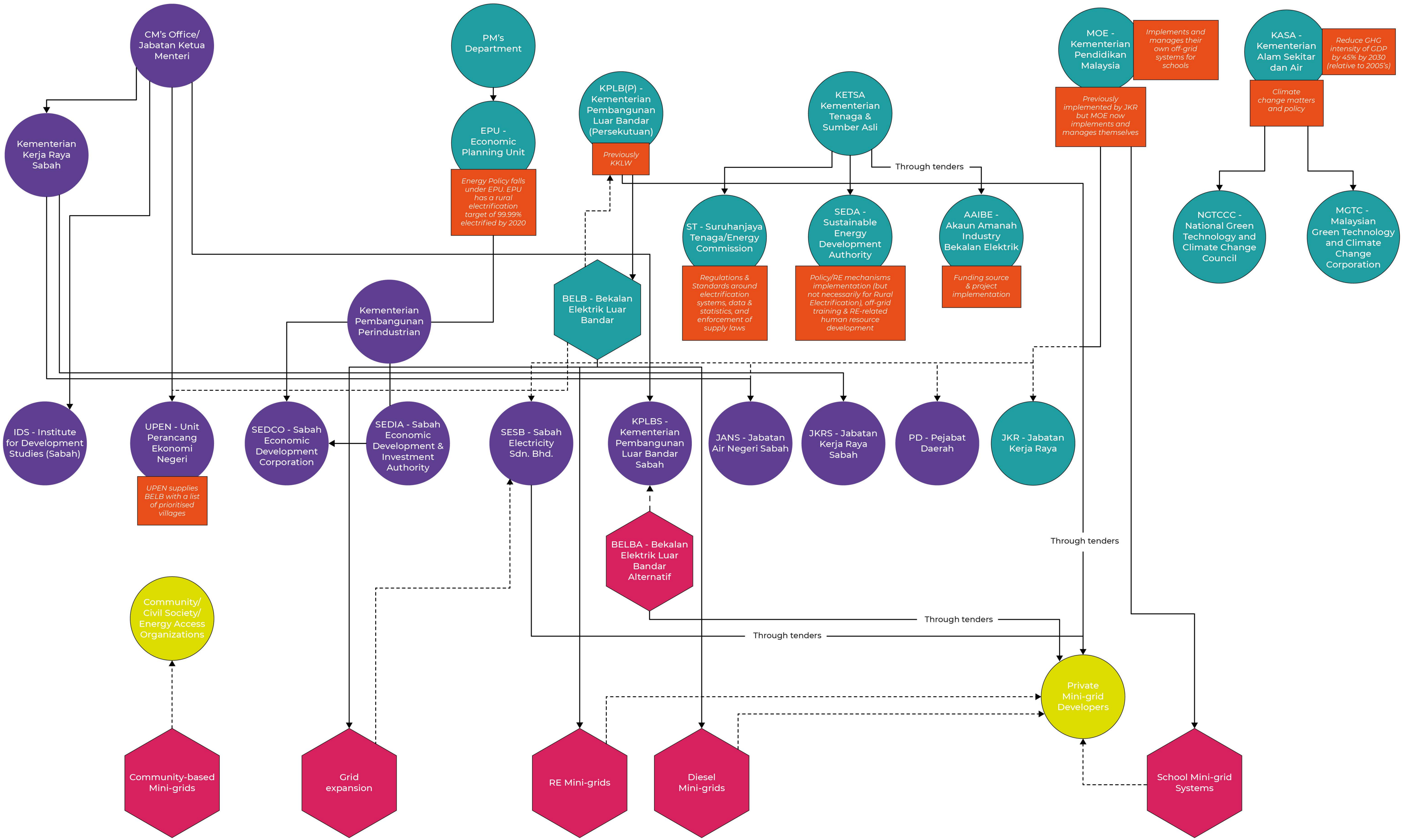

Figure 1. Stakeholder Policy Map

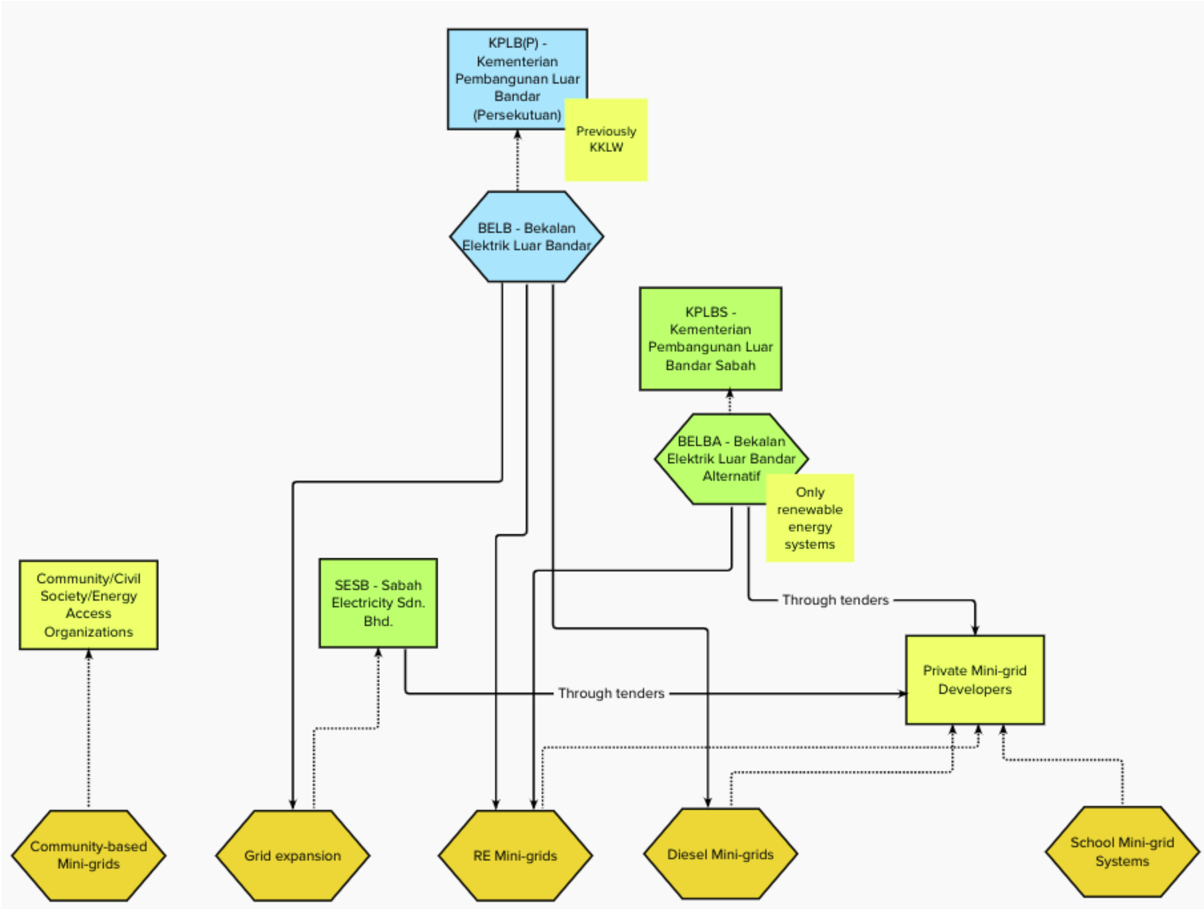

Figure 2. Rural Electrification in Sabah

The above Figure 1. Stakeholder Policy Map describes the political, governing and coordinating landscape, and lists the many entities involved in rural electrification in Sabah. As can be seen from the figure, there are up to five federal ministries and agencies with varying levels of involvement in rural electrification efforts: the Prime Minister's Department, KPLB, Ministry of Energy and Natural Resources or *Kementerian Tenaga dan Sumber Asli* (KETSA), Ministry of Education (MOE), and Ministry of Environment and Water or *Kementerian Alam Sekitar dan Air* (KASA). There are a number of agencies, units and departments under each of those ministries involved in policy-setting, delivery and implementation of various policies and programmes.

Although the national Rural Electrification Programme or BELB falls under the scope of KPLB, national energy policy is developed by the Economic Planning Unit (EPU) under the Prime Minister's Department. Regulation and enforcement of electricity supply laws, as well as energy policy and renewable energy mechanisms implementation is under KETSA, while climate change-related policies are developed by KASA.

At the Sabah state level, there are a number of agencies and departments involved in rural electrification delivery and programmes, including SESB, state-level ministries such as the Ministry of Rural Development Sabah or *Kementerian Pembangunan Luar Bandar Sabah* (KPLBS), State Economic Planning Unit or *Unit Perancang Ekonomi Negeri* (UPEN), Public Works Department or *Jabatan Kerja Raya*, as well as local District Offices or *Pejabat Daerah*.

With the multiple federal agencies involved, the Stakeholder Policy Map depicts the level of complexity and coordination necessary to deliver rural electrification activities. Clear boundaries between the agencies need to be defined and communicated to avoid overlapping and duplicated efforts, as well as inefficient use of resources.

The Stakeholder Policy Map also demonstrates that decision-making when it comes to energy policy and targets, electricity supply and distribution regulations and standards, as well as budget allocation for BELB occurs at the federal level. While this is meant to support coordination and policy integration at a higher level (e.g. ensure that mini-grids are not implemented in areas to be connected to the grid within 10-15 years), this also means that without strong data, evidence and feedback loops, the realities of ground-level implementation are rarely taken into account when setting higher level policies and strategies. There are some very real challenges and realities in Sabah that are not currently being reflected in decision-making. As long as decision-making and regulation remains at the federal level, state-level agencies and stakeholders have limited ability to leverage local capacity and knowledge to firstly identify or confirm local needs and priorities, develop more sustainable, localised and cost-effective solutions, and lastly implement them efficiently and effectively.

There has recently been some acknowledgement of the need to move decision-making and regulation to the state. In the last year, the Sabah State Attorney General has drafted three enactments, including a Sabah State Energy Commission Enactment and an Electricity Supply Enactment that may shift some decision-making and regulation to Sabah. In April 2021, the Sabah Cabinet also approved a *Unit Tenaga* under the CM's Office that will provide technical input into the draft enactments. It is believed that the *Unit Tenaga* will eventually transition into the role of a state-level Energy Commission with regulatory authority and oversee the transfer of SESB ownership. The *Unit Tenaga* could play a key role in developing and clarifying code and regulations for renewable energy mini-grids in Sabah, under the new enactments.

Policy Recommendations

The rate at which electrification efforts are being implemented in Sabah requires acceleration in order to ensure that Sabah's rural populations achieve universal access within the decade. Over the years, existing renewable energy mini-grid initiatives in Sabah (both public and privately installed systems) have demonstrated mini-grids' potential for improved cost-effectiveness, and fit and alignment with local community priorities and needs, particularly for remote communities too far from the grid.

Mini-grids have a wide range of both technical and delivery model flexibility and complexity. With recent advancements in renewable energy technology and mini-grid business and delivery models, there is potential for further cost reductions and overall sustainability if mini-grid initiatives and efforts are well-designed and coordinated to take advantage of these advancements. This is in line with many other countries' strategies to utilise renewable energy mini-grids for rural electrification. The International Energy Agency (IEA) estimates that over 70% of unelectrified and new connections will be served by off-grid or mini-grid systems by the year 2030 [27].

In addition to mini-grids for rural electrification, there is also a growing recognition among the international energy community that renewable energy mini-grids will play a key role in decentralisation and democratisation of national energy systems. Decentralisation of energy can reduce costs, provide greater resilience and flexibility, and support higher penetration of renewable energy, all of which contribute towards Malaysia's energy transition.

While there is national recognition and acknowledgement of the urgent need for rural electrification in Sabah (e.g. as restated in RMK 12) this has thus far been translated into a roadmap that continues the BELB in the BELB Masterplan Year 2021 to 2025. However, with both BELB and private or NGO-based mini-grid implementation, rural electrification efforts have been extremely costly and slow. This is largely attributed to a fragmented energy ecosystem, and a policy and regulatory environment that does not support nor facilitate more cost-effective rural electrification solutions such as mini-grids.

Sabah's main grid has also experienced frequent service disruptions due to damage from floods and fires, which will likely be exacerbated by climate change. There is also an urgent need to incorporate considerations related to climate resilience in rural electrification and overall energy system planning. Mini-grids offer increased resilience when factoring in long-term costs related to potential damage to assets, disruptions to fuel supply, water shortages, and other climatic factors.

To address rural electrification through mini-grids, accelerating and enabling mini-grid deployment at scale is required. The following table describes the main barriers to scaling up mini-grids for rural electrification in Sabah, as well as some recommendations to address them.

Main Barriers to Mini-grid Scale-up	**Recommendations**
Current Sabah rural electrification programme, planning and coordination excludes communities and other stakeholders and potential actors	**An updated roadmap with goals and an implementation plan that incorporate multi-stakeholder input** is required to ensure a well-designed and coordinated delivery programme for rural electrification. ● Targets and goals need to be updated to **include an equitable and just 100% rural electrification target using renewable energy by 2030**. While the current target of achieving 99.9% rural electrification by 2025 is not far from 100%, there is significant potential to achieve 100% using renewable energy distributed systems, aligning the state's rural electrification programme with broader sustainable development goals and a just energy transition. ● **Include socio-economic and sustainability goals** to ensure early consideration of socio-economic opportunities. ● A roadmap with multi-stakeholder input requires collaboration and coordination from entities such as: SESB and ST (grid planners); UPEN, KPLBS and KPLB (rural development agencies); community-based organisations (with knowledge of and representing

	communities' energy needs and demand); energy access practitioners and mini-grid developers (with on the ground experience in implementing projects); and other stakeholders.
The current rural electrification delivery programme with its focus on grid extension is costly and slow for rural areas. The single owner system also adds costly operational challenges when deploying distributed systems, and does not take into consideration locally available resources and other delivery models.	**A least-cost approach to rural electrification that prioritises mini-grids as a viable solution** is needed. ● **Prioritise mini-grids** as Sabah and BELBs' main strategy for rural electrification. KPLBS' BELBA program is a move in this direction, and has the potential to become KPLB's primary method for rural electrification. However, it will require coordination between KPLB (a federal-level ministry) and KPLBS (a state-level ministry under the Chief Minister's Office) to ensure that sufficient financial resources are allocated towards BELBA and that site selection and planning involves SESB. ● **Include more innovative business and operational models[19] in rural electrification**, moving beyond BELB's traditional programme delivery model. The existing project tender process that BELB utilises is aimed at ensuring that bids are reasonably priced and meet safety and technical standards. However, these tenders are designed to only deliver connections and remain somewhat costly by not taking full advantage of mini-grids' high degree of flexibility. A new programme delivery model could take into account key mini-grid success factors such as substantive community involvement and engagement, strong local technical capacity, early incorporation of economic development opportunities into planning (i.e. productive end use and anchor clients) and follow-on support for productive use development. In addition to this, successful scaling up of mini-grids could include bundling and aggregation of projects into portfolios with different technologies that serve different community needs or levels of service, and a long-term view on monitoring project performance, and collection of information and documenting best practises to facilitate improved mini-grid deployment. ● **Include other stakeholders and actors** such as community-based organisations and smaller mini-grid practitioners in delivery. With new operational, business and delivery models, different combinations of operational and management models could be included in order to reduce costs and leverage more local technical capacity. A brief description of possible operational models is included in the Annex: Mini-grid business and delivery models.

[19] See Annex: Mini-grid business and delivery models for some conventionally used operational models.

	Apply a comprehensive, least-cost approach that takes into consideration total system lifetimes, socio-economic opportunities and benefits to reduce costs in rural electrification planning and implementation. Grid extension historically benefits from economies of scale and is cost-effective in urban areas with high population density. However, remote communities can be very expensive to electrify through grid extension and off-grid and distributed systems can offer significant cost savings [28]. As can be seen from Table 1. Existing rural electrification initiatives in Sabah, allocations for rural grid extension in Sabah are as high as RM100,000 per household connection (compared to RM80,000 in Peninsular Malaysia), reflecting higher implementation costs in Sabah. However, based on existing installations, the average upper limit costs for mini-grids is approximately RM65,000 per household connection. Mini-grid costs can be further reduced with improved system sizing and design, responsiveness to local needs (e.g. directly addressing and serving end user demand to ensure energy generated is fully utilised), some standardisation of designs and construction methods without compromising flexibility and level of service, and leveraging local communities' capacity and resources to operate and manage mini-grids. **Incorporate data- and evidence-based planning and decision-making** for rural electrification, such as state-level techno-economic optimisation models with high resolution of demand. Existing energy planning tools can be used to develop and evaluate data-driven models that take into consideration community demand profiles and optimise for best fit and financially viable mini-grid technologies based on available local resources (e.g. biomass, hydropower, solar).
Lack of investment and finance	Build out an **efficient and transparent delivery model to attract investment** and encourage private and international funding through a delivery programme that derisks investment and complies with international standards. **Innovative business and delivery models** (i.e. different combinations of ownership, financing, operational models & technology based on local needs) could provide new and different financing options for systems, including private sector investment. - BELB systems are currently publicly funded and therefore do not employ cost-reflective tariffs, while grant-based community systems typically establish community funds to cover basic

	operations and maintenance. There is potential to charge more cost-reflective (but community-accepted tariffs) and incorporate financial incentives for project developers, especially if systems are holistically developed to include communities' productive end use, micro-enterprises and anchor clients when possible. ○ As previously mentioned, different ownership and management structures could also reduce costs and risks for investors by leveraging local (skilled) operators and management, removing the need for SESB to spend on costly O&M in remote areas (examples of delivery models are described and discussed in the Annex). ● **Build strategic partnerships among stakeholders** to leverage diverse experiences and resources. A new programme delivery model would require building new partnerships and collaborations between institutions and stakeholders to improve planning, coordination and closed feedback and information loops. ○ Build synergy with other non-energy sectors and programmes in the rural development space that could benefit from more affordable and stable sources of energy (e.g. schools and rural businesses), as potential anchor clients for mini-grids. Other non-energy programmes (e.g. government initiatives to support small to medium enterprises or SMEs) could also help support activities such as productive end use development or targeted business support in mini-grid communities, which increase livelihoods and ability to pay for electricity services in rural areas. ○ Private sector participation in rural electrification thus far has been limited to Corporate Social Responsibility (CSR) projects or participation in tenders. However, with recent trends in corporate Environmental, Social and Governance (ESG), innovations in business and operational models could encourage private sector participation and investment. ○ Including project developers, community service organisations and energy practitioners who have deep knowledge and experience implementing projects on the ground would support a programme that better meets community needs.

	A Sabah-based and -initiated collaborative and multi-stakeholder approach to sustainable rural electrification demonstrates a bottom-up and evidence-driven approach to sustainable energy planning. This also supports structural changes to Sabah's power sector towards democratisation and sovereignty of the state's energy system, leapfrogging the rest of the country to join similar trends in other countries. ● **Improve and establish methodologies for calculating energy sector emissions**, to access renewable energy credits and other international renewable energy financing. At the recent COP26, Malaysia highlighted its ambitions to focus on carbon markets and financing to reach its climate goals. However, carbon financing is a nascent space in the country. Improved methodologies can significantly contribute to local carbon market development, while opening up near-term access to international market-based programmes such as renewable energy credits for mini-grids. ● **Capitalise on the potential conservation benefits of rural mini-grids,** particularly micro-hydro systems, to incentivise protection of water catchments and access Payment for Ecosystem Service or other conservation-based financing mechanisms. ● **Increase public investment and finance** in rural electrification, especially in the next 5-10 years to achieve universal access and reach areas that are still unelectrified. With new business models in place, there are multiple mechanisms that the government can take advantage of to support financing rural electrification such as low interest financing, tax incentives for mini-grid project developers. Funds such as AAIBE could also be used to subsidise tariffs for rural users, as mandated in the Electricity Supply Act[20]. Energy poverty is an urgent issue that needs to be addressed as quickly as possible. There are approximately over 400 villages (over 120,000 people) in Sabah still without access to modern energy services, essential in enabling healthcare, education, economic opportunities and political agency. Gaps and disparities are further exacerbated during emergencies and crises such as the global COVID-19 pandemic. For many in rural areas, the lack of access to electricity during COVID-19 meant being even more cut off from critical health-related information and services during a time when up-to-date guidelines and directives meant the difference between life and death. There is also a huge opportunity cost when such a large number of the

[20] According to the Electricity Supply Act, the AAIBE fund can be used to 'manage the impact of electricity tariff on consumers'.

	population has limited socio-economic opportunities and is unable to participate in the broader economy. With a rural population of almost 40%, Sabah's rural economy holds great potential to contribute to sustainable development in the state, especially in the agricultural sector.
Uncertain policy and regulatory environment for mini-grids, which increases the risk of unsafe and unreliable system installation and operation, as well as imposes a high entry barrier for participation	**Develop and clarify stakeholder roles, project guidelines, streamline project implementation, and develop and implement a mini-grid quality assurance framework** for rural electrification activities. ● **Formulate appropriate mini-grid regulations and project implementation guidelines** to facilitate an enabling environment for rural electrification mini-grids. As previously mentioned, the current regulations and guidelines are limited for mini-grid roll-out and deployment. The following are suggested clarifications, and refined regulation and/or guidelines for mini-grids (under 72 kWp): ○ Allow micro-utilities for rural, off-grid systems. This would require clarification of licensing for electricity supply and sales as well as allow appropriate tariff setting. ○ Licensing to go through state actors. Public installation licence applications are currently processed by federal-level ST. State-level decision-making and regulation would ease and improve mini-grid deployment. ○ Consider mini-grid registration instead of licensing to reduce the administrative burden for both the regulatory body and project developers/operators [29]. ○ Clarify rules and regulation around Environmental Impact Assessment (EIA) requirements for micro-hydro systems. ○ Develop streamlined project implementation for lower tier mini-grids to reduce barriers for delivery partners. ○ Develop training and relevant certifications for mini-grid ecosystem actors, including community mini-grid operators. ○ Clarify options for mini-grids when the grid arrives. There are multiple options for mini-grids once the main grid arrives such as continuing to operate alongside the main grid, the mini-grid interconnects and sells electricity to the main grid, the mini-grid stops producing and only distributes, or mini-grid assets are moved to another site.

	● **Develop a quality assurance framework** to ensure health, safety and environment requirements are met. The current codes and standards are insufficient to ensure safe and reliable operation of community-scale mini-grids for rural electrification. However, considering the wide range of both technical and delivery model flexibility and complexity with mini-grids, it may not be appropriate to detail new technical standards with a high degree of specification for mini-grids. Defining different levels of service and using a mini-grid quality assurance framework, as proposed by the US National Renewable Energy Laboratory (NREL) [30] rather than very specific technical standards, would be more appropriate and allow for a high degree of technical and delivery model flexibility. This would also help reduce the entry barrier for lower-tier mini-grids with lower technical complexity [31] while still maintaining safety. A quality assurance framework with clear reporting mechanisms for monitoring and evaluation that works within existing codes and standards is sufficient to ensure safety and service quality. ● **Improve coordination and define roles, responsibilities and relationships** among relevant ministries, agencies and stakeholders. In addition to an updated roadmap and programme delivery model, the roles and involvement of the different stakeholders must be clearly defined to ensure successful implementation. As previously highlighted, this would also involve active inclusion and involvement of stakeholders such as project developers and community-based energy practitioners, beyond just as implementation partners. The following lists potential key stakeholder involvement and roles in enabling mini-grids [30] : ○ Government - ■ Policy-setting and roadmap planning ■ Development and enforcement of rules and regulation around mini-grids ○ Government and/or utility, with some involvement from project developers - ■ Information gathering and needs assessment ■ Project monitoring and reporting, which contributes to long-term energy planning ○ Government and/or investors -

	■ Funding for mini-grid projects, services to support mini-grid scale-up, technology and service providers ○ Utility and/or project developers/energy practitioners - ■ Mini-grid project development, installation and operation ■ Management and operation of systems may be commercial undertakings ○ Energy service end users - ■ Awareness and articulation of energy priorities and aspirations ■ Participation and involvement in community-focused management and operations of mini-grids ■ Potential paying customers who will also report issues to the service provider Roles and responsibilities around planning and decision-making should be played by state-level actors (e.g. KPLBS, UPEN or SESB with input from other stakeholders) to ensure that information and feedback informs planning and coordination. ● **Support technology development and market**, aligned with safety regulations and standards. Currently, many mini-grid components (especially for solar systems) and hardware are imported into Sabah, which drives up the cost of systems. Support for local manufacture of components (e.g. micro-hydro turbines) can take the form of technical capacity building and training or reducing import costs.

Table 2. Main barriers to mini-grid scale-up and some recommendations.

Next Steps

Based on the recommendations above, the Sabah Renewable Energy Rural Electrification Roadmap consortium proposes an updated mini-grid-based rural electrification roadmap and delivery programme that is cost-effective, socially inclusive and sustainable. The main highlights of this delivery programme include the following:

- Utilise and leverage local resources and capacities
- Develop project profiles and portfolios that directly meet community needs and priorities and integrate socio-economic opportunities for financial sustainability
- Provide at least Tier 4 (>800W/3.4 kWh per household) electricity access
- Develop sustainable business models with community acceptance, and multi-stakeholder involvement
- Formulate and ensure a mini-grid quality assurance framework that ensures standards, safety and reliability as approved by ST

- Support delivery by clarifying implementation guidelines and facilitating a streamlined process within existing regulations (for systems under 72 kWp)
- Provide additional support and capacity building for delivery and implementation

As continuation of this work, a proposed programme delivery model has been developed and is detailed in Annex: Proposed multi-stakeholder programme delivery model.

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Annex

Mini-grid business and delivery models

The following Table 3 describes some existing business and mini-grid delivery models currently used worldwide. In defining an operational model, these roles and responsibilities need to be well-defined: Funder, Developer, Owner, Operator, End users.

Model	**Pros**	**Cons**
1. Utility	● Experienced, with more capacity ● Usually more established	● Governed by political agenda ● Market-driven (low rural electrification priority)
2. Private	● May have better operational/management capacity ● Incentivised to promote financial viability	● Lack of financial support
3. Community - Co-operatives - Community-owned management committee - Housing associations	● Buy-in/Sense of ownership ● Reduces bureaucracy	● Lack of technical skills ● Governance and social conflicts
4. Hybrid - Public-private partnerships	● Opportunity to combine different strengths and advantages	● Inclusion of multiple entities could increase (transaction) costs ● Need to balance different interests

Table 3. Mini-grid operational models

Proposed multi-stakeholder programme delivery model

The following figures are part of this consortium's ongoing work towards rural electrification efforts in Sabah. As described and highlighted in this document, an innovative multi-stakeholder approach is required in planning, coordination and implementation of rural electrification initiatives. Figure 3. describes a first stage delivery programme that prioritises alternative funding sources (other than public funding), a multi-stakeholder advisory board, and a community-focused implementation model. In contrast to the BELB and BELBA, coordination and management of tenders is managed by an entity under the oversight of a multi-stakeholder committee. There is also a focus on capacity building, and training of project delivery or implementation partners, who are expected to work more closely with communities to develop systems. Innovative business and delivery models will be employed, trialling new tariff models to access alternative financing options.

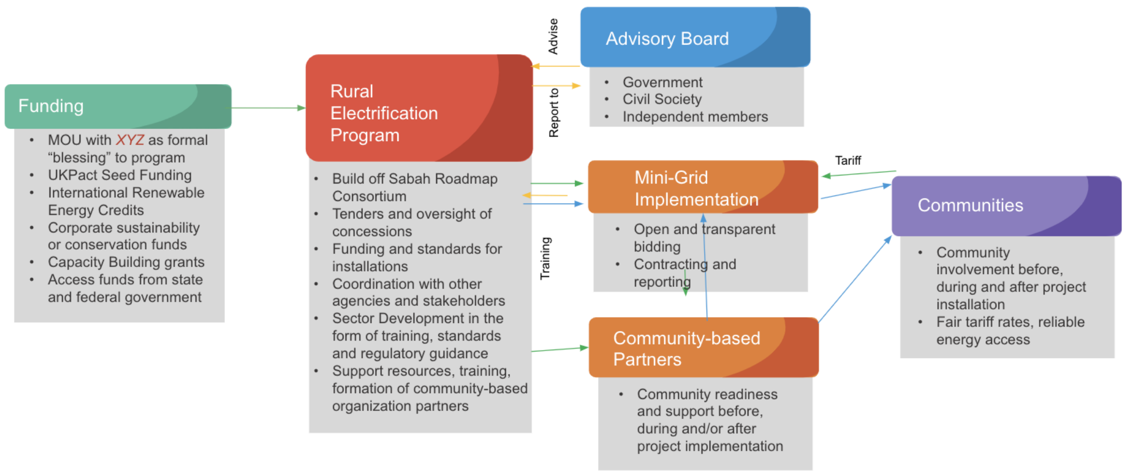

Figure 3. First stage programme delivery model

Figure 4. describes a next stage or aspirational programme model that builds on the earlier stage to roll-out and manage a larger number of projects and systems. It is expected that in this stage, funding flows are better established and that earlier projects have produced learning and feedback towards broadening the scope of the programme. This aspirational model anticipates a thriving ecosystem with participation and inclusion from as many stakeholders as possible.

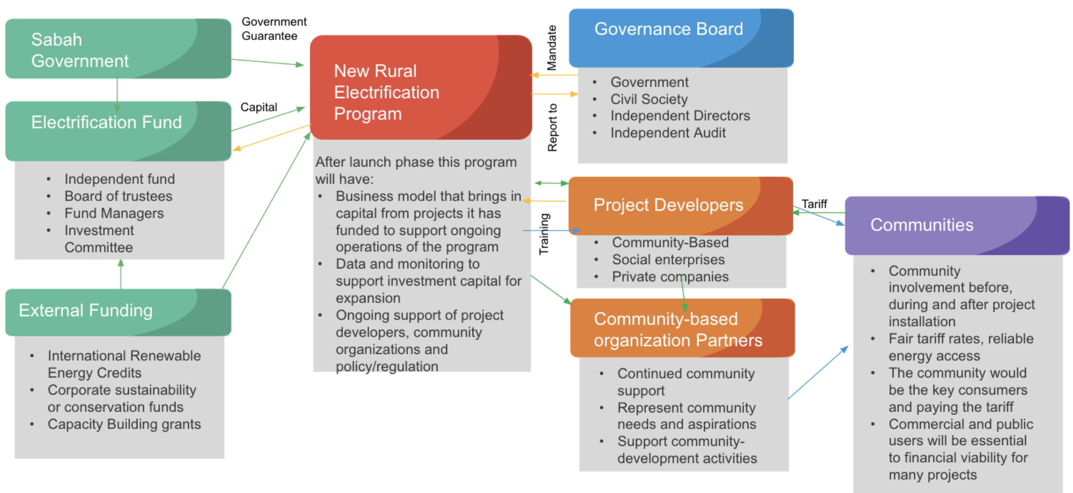

Figure 4. Aspirational programme delivery model

At the project level, the delivery programme takes advantage of different combinations of ownership and operational models as described in Figure 5. below. The Rural Electrification Programme manages a portfolio of projects and tenders, open to mini-grid developers and practitioners who fulfil programme requirements. Unlike BELB, programme requirements include community inclusion and involvement as well as an operational model that fits community profiles, expectations and acceptance. These operational models allow for a range of possibilities such as community ownership and management, community ownership and management by a micro-utility, ownership by a micro-utility or the main utility (SESB) with system management by the local community, or ownership and management by a micro-utility or SESB and the community as end users. The programme also enables project developers to set tariffs, within programme-defined guidelines and communities' ability to pay. Mini-grid development and operations will also follow a quality assurance framework set by the programme.

The consortium aims to work closely with regulatory bodies and SESB to ensure that this programme sufficiently meets basic code and safety standards around electricity supply. As licensing and regulations are limited or unclear for mini-grids, it is expected that the proposed delivery programme may support development of new guidelines, without needing new legislation amendments in the near future.

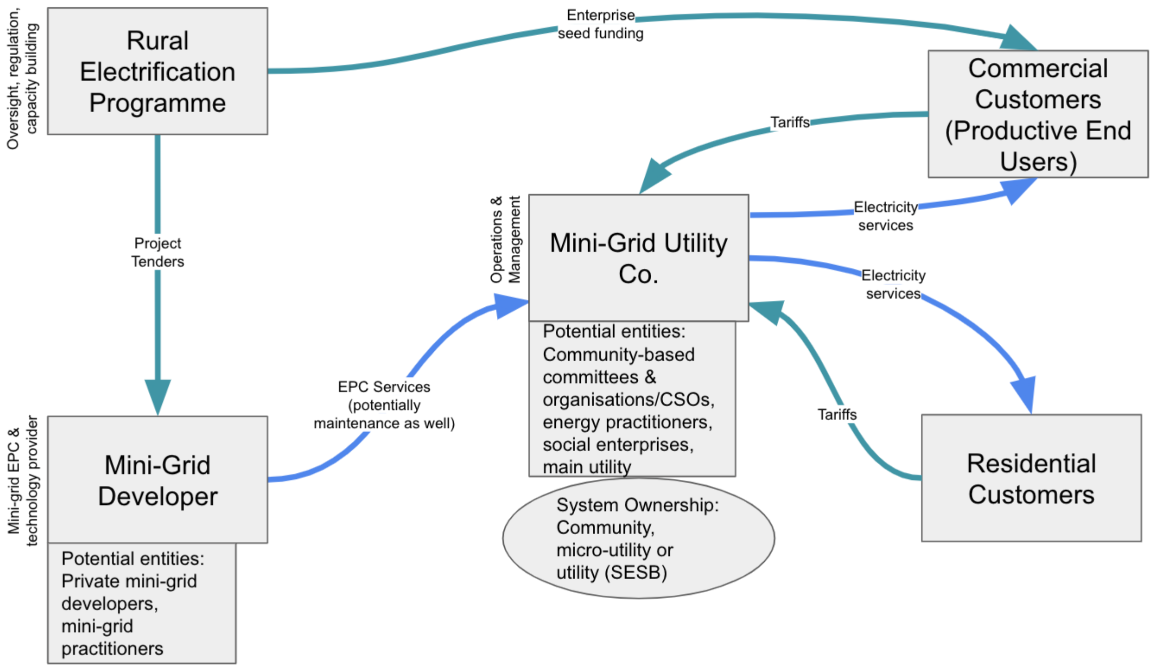

Figure 5. Project-level delivery model