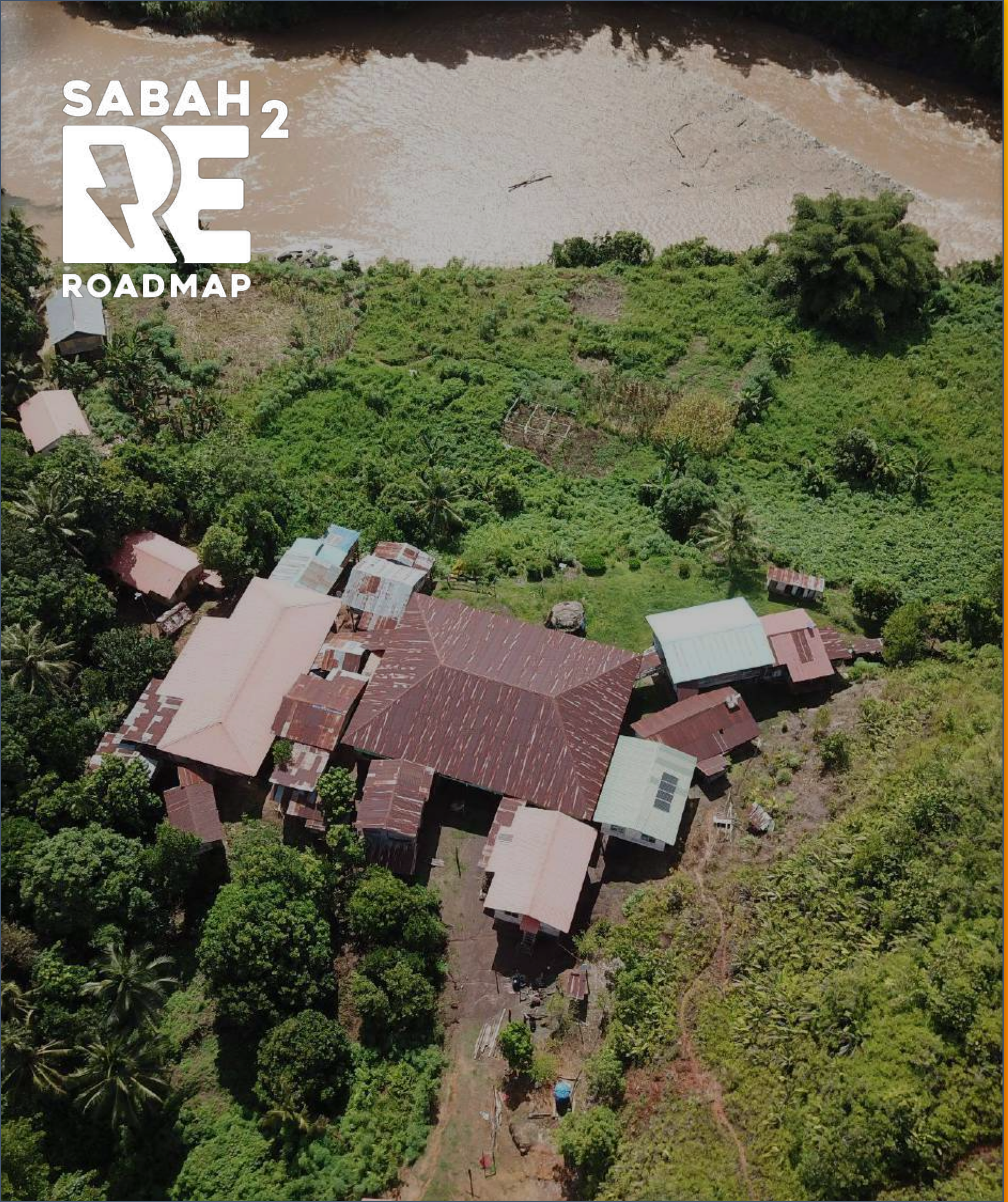
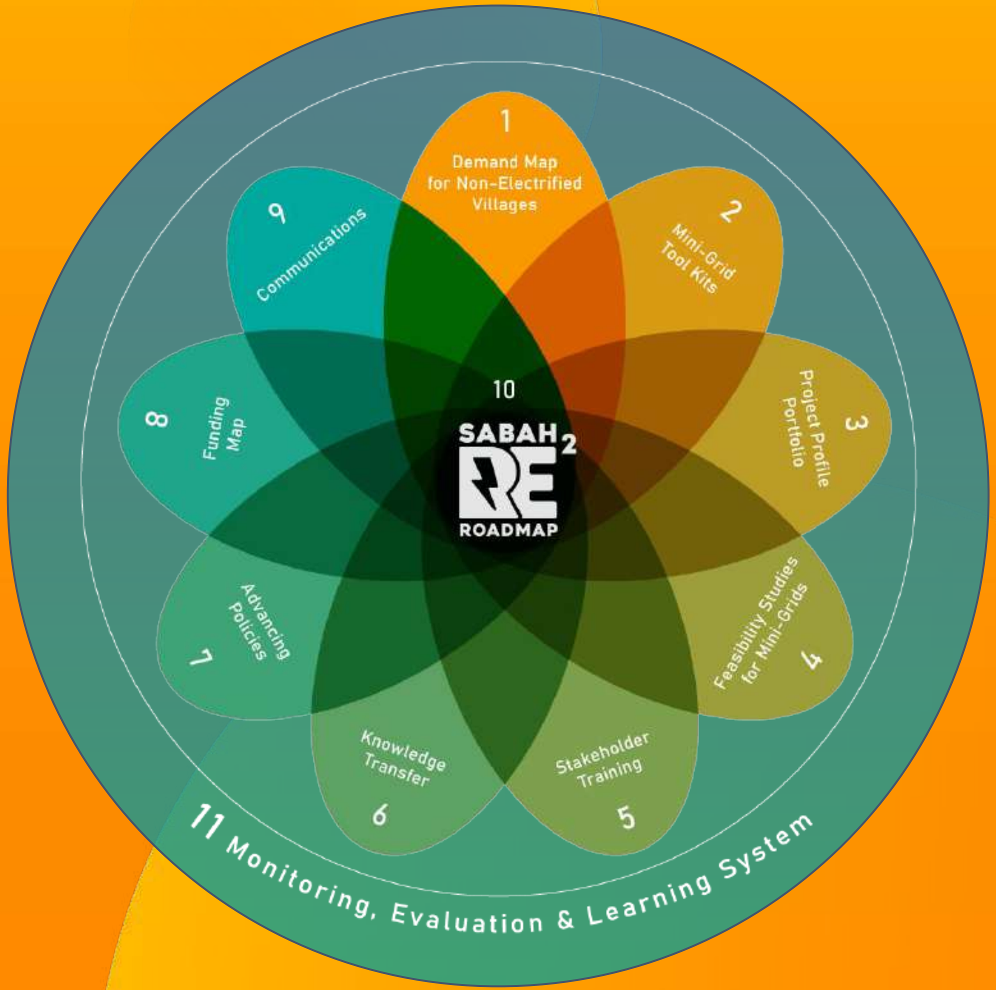


SABAH RE2 ROADMAP

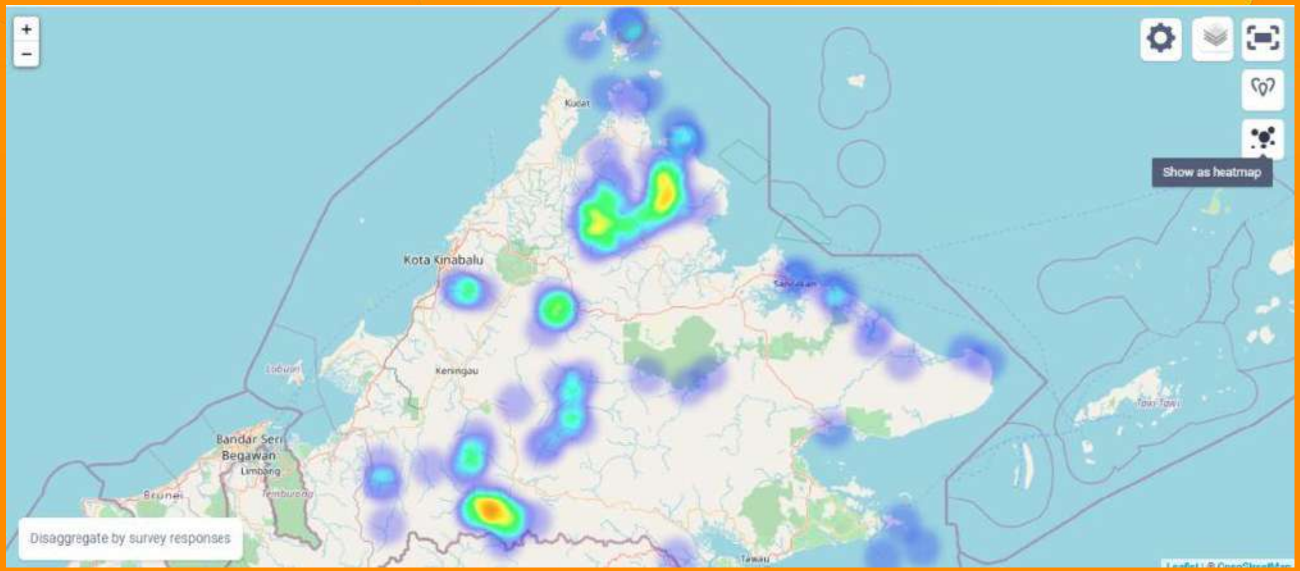
2022-2030

www.sabahre2roadmap.org

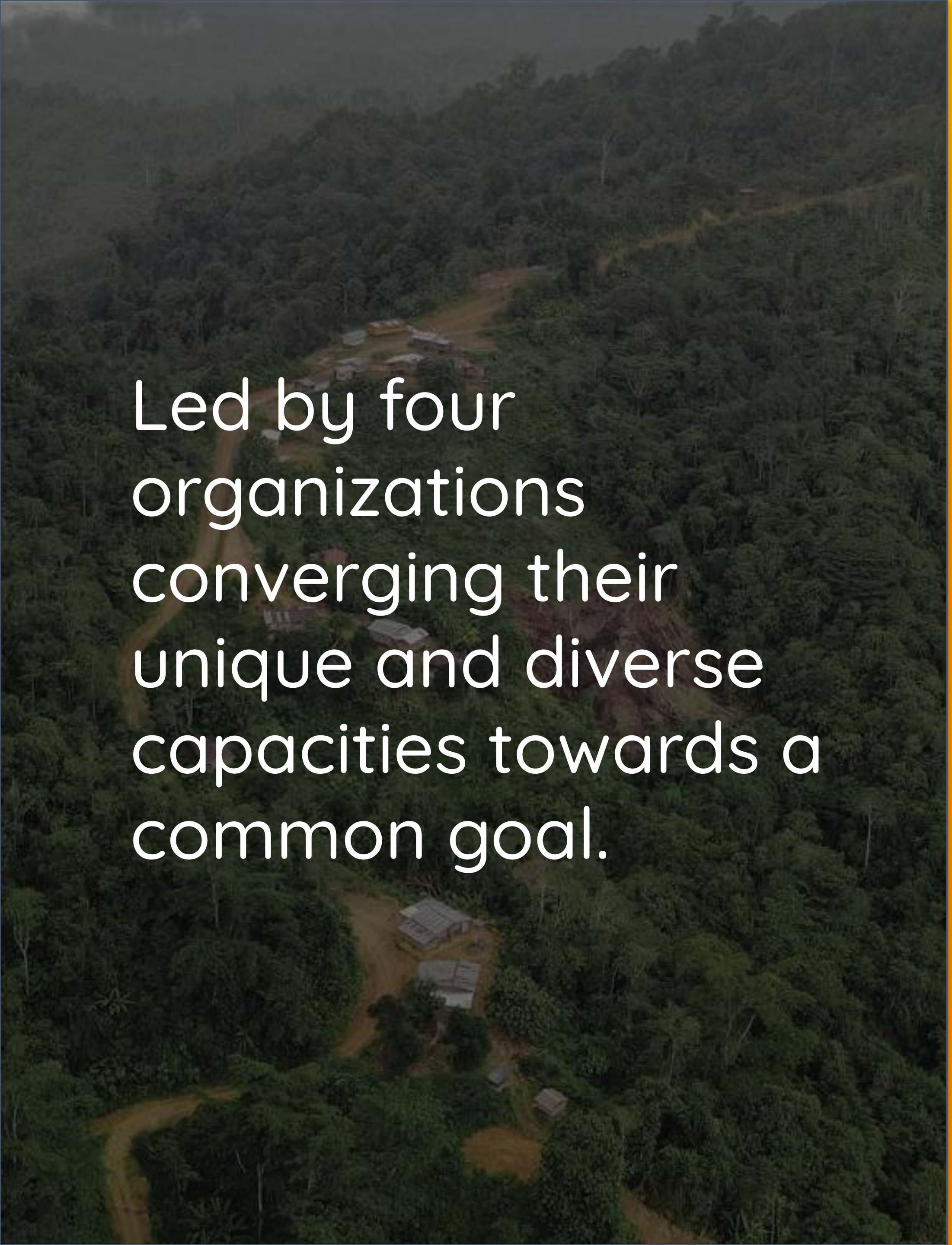


Sabah Renewable Energy Rural Electrification Roadmap

is a multi-stakeholder initiative that charts a course for energy access for all in Sabah. The roadmap provides the tools, data and approaches required to optimize renewable energy deployment in rural Sabah, and connects climate change mitigation with energy justice, local economies and environmental stewardship.

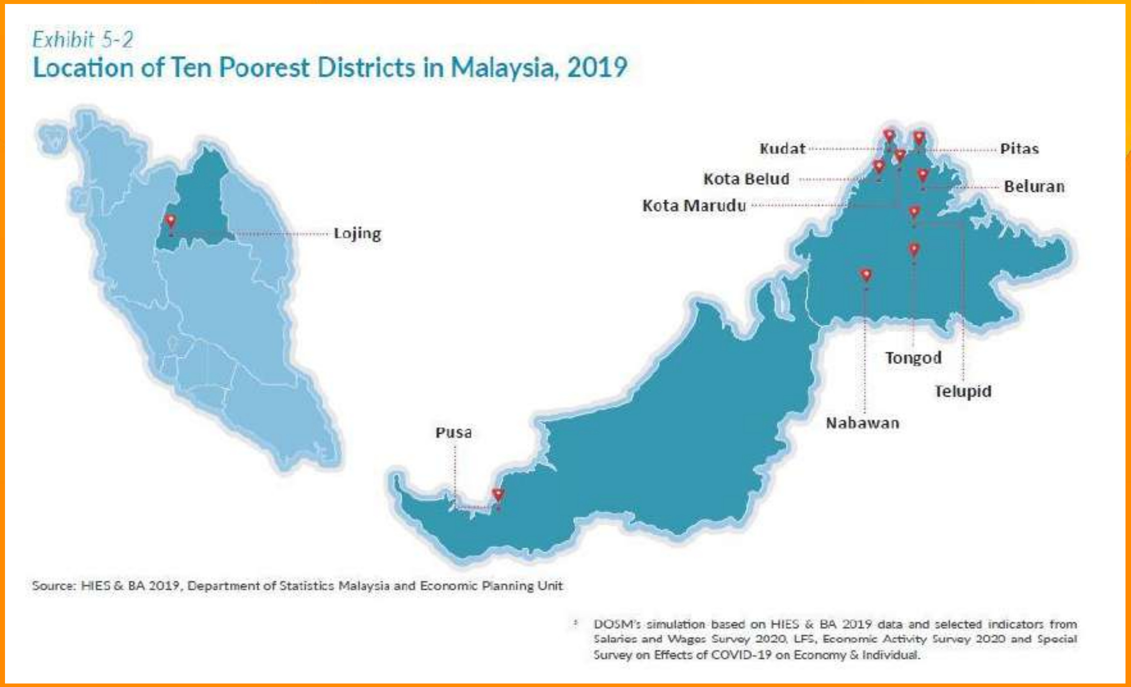


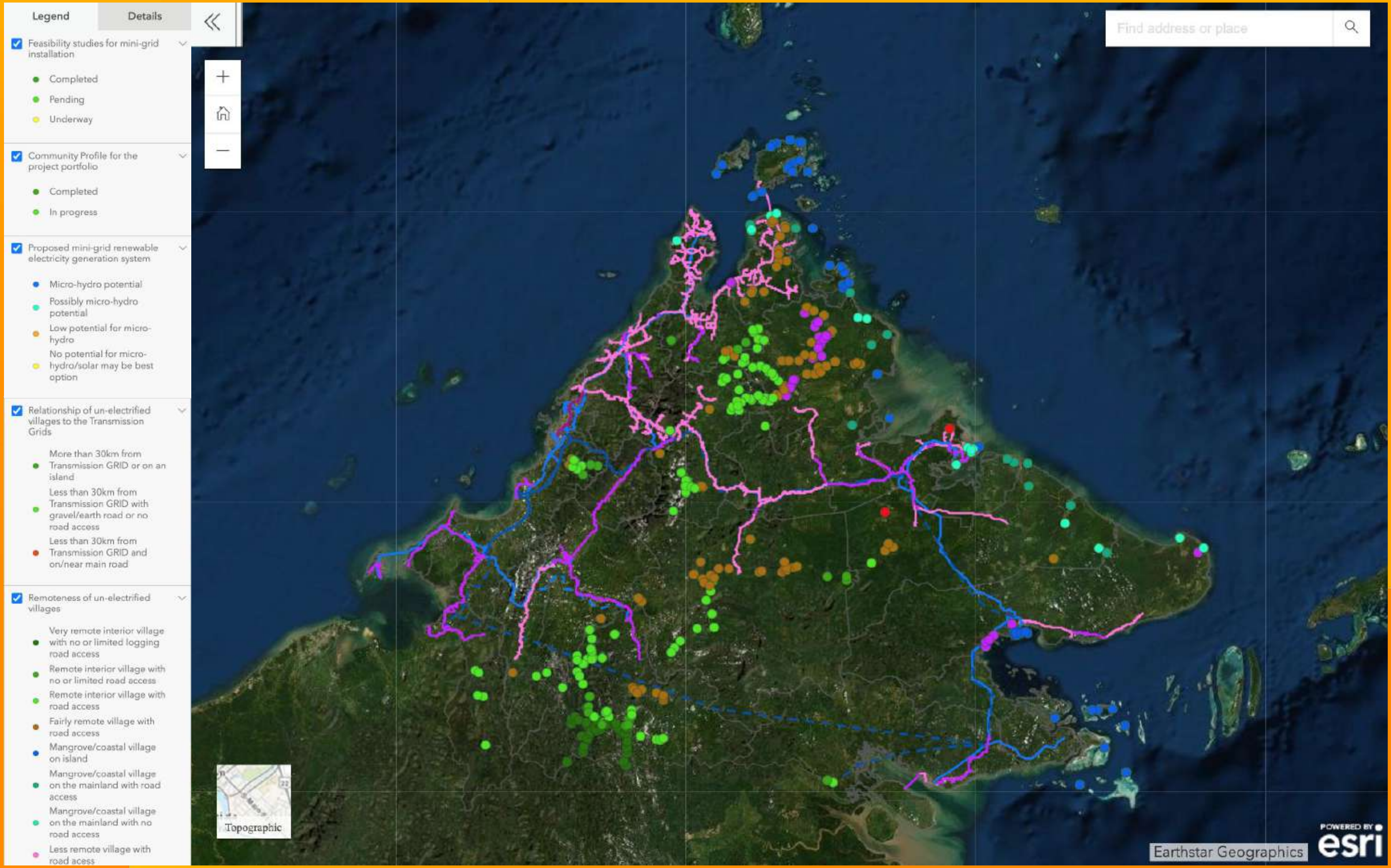
sabahre2roadmap.org



Led by four organizations converging their unique and diverse capacities towards a common goal.

Sabah is home to 72% of unelectrified rural Malaysians, and 8 of 10 poorest districts in Malaysia (12 Malaysia Plan). Our demand map (heat map in previous slide) has identified these communities, and the roadmap creates the pathway to energy access for them.

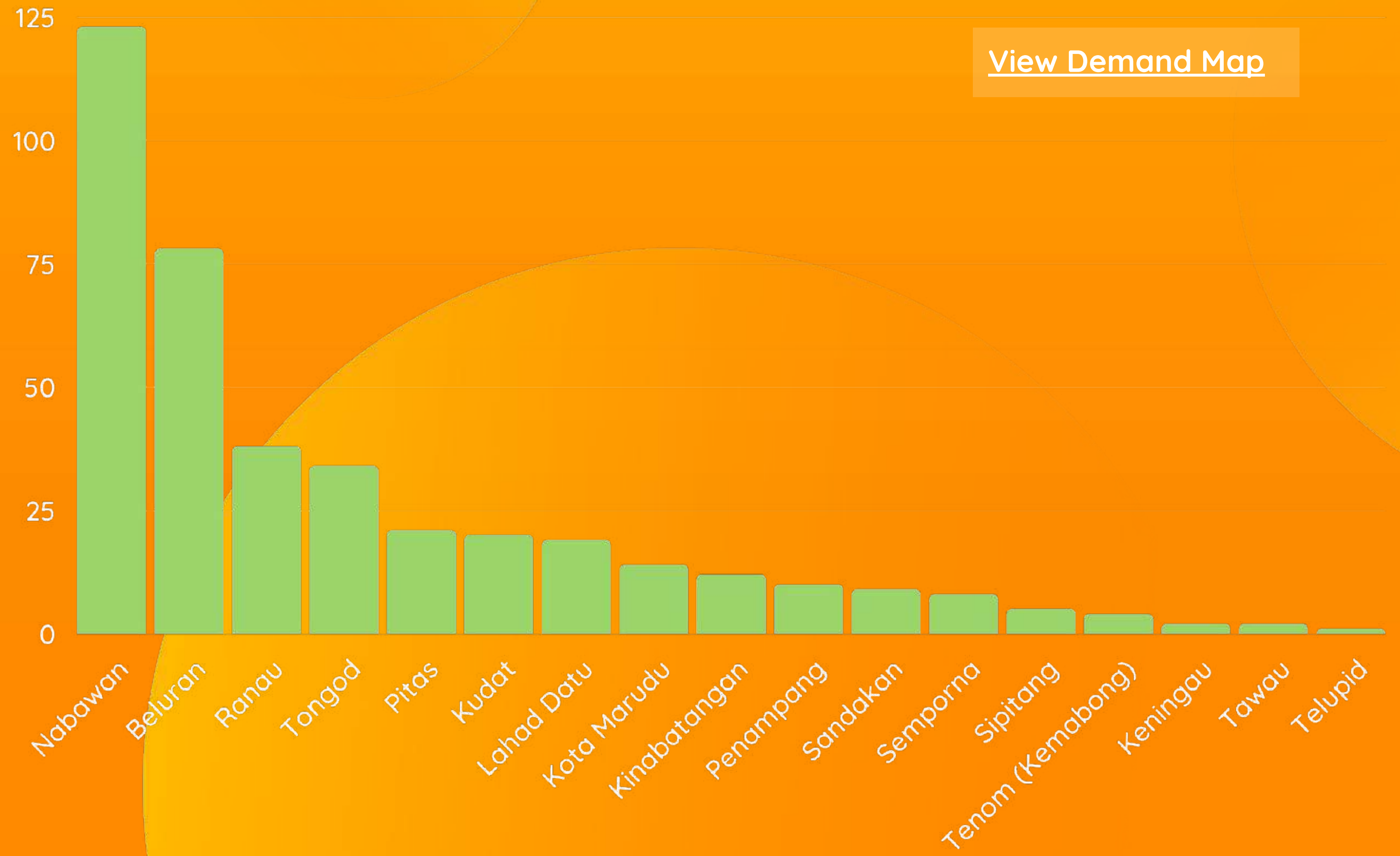




Energy Access Demand Map of Sabah

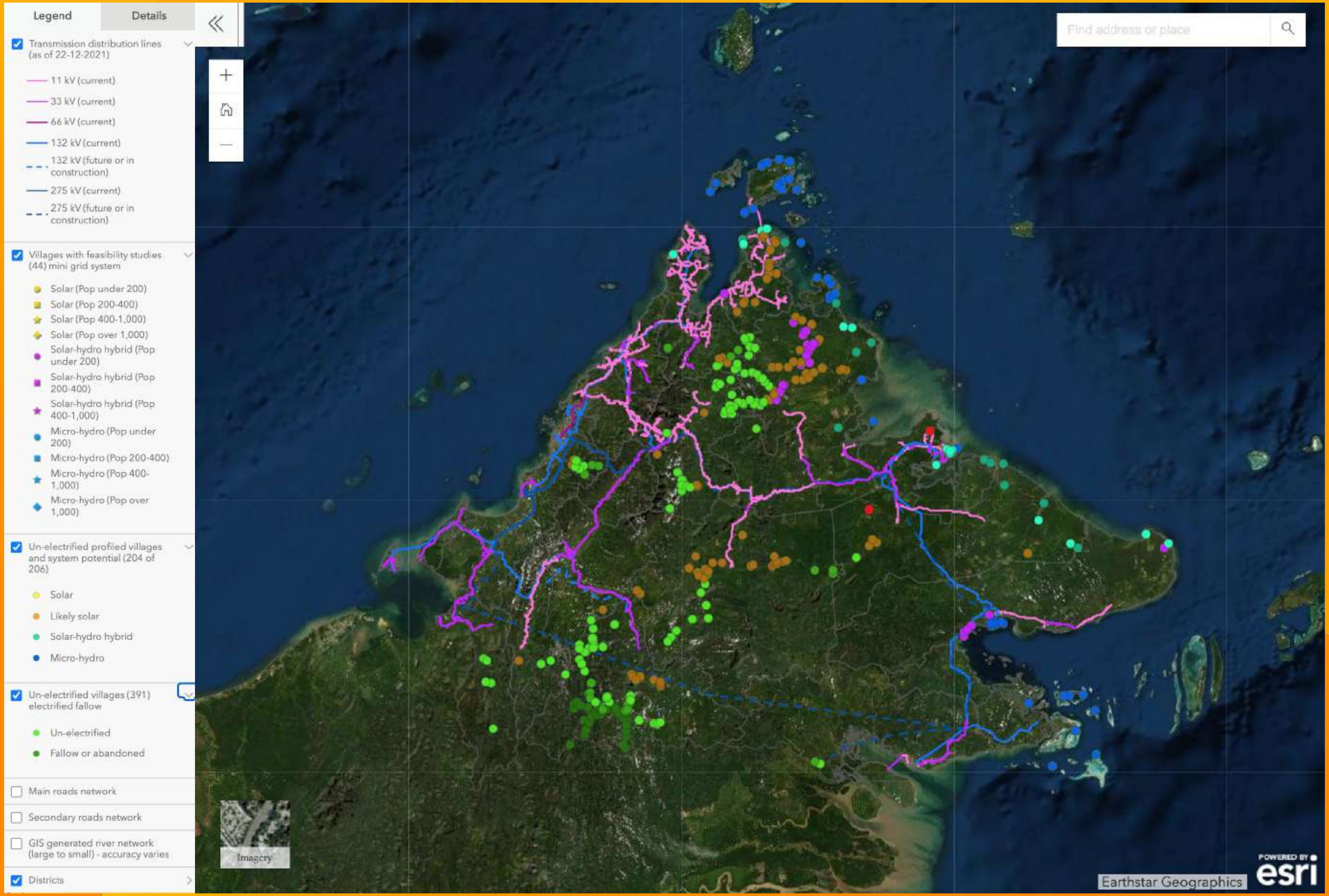
View Full Map

Numbers of Un-Electrified Villages by District (Total Demand Map Villages - 400 with approximate population of 120,000)



View Demand Map

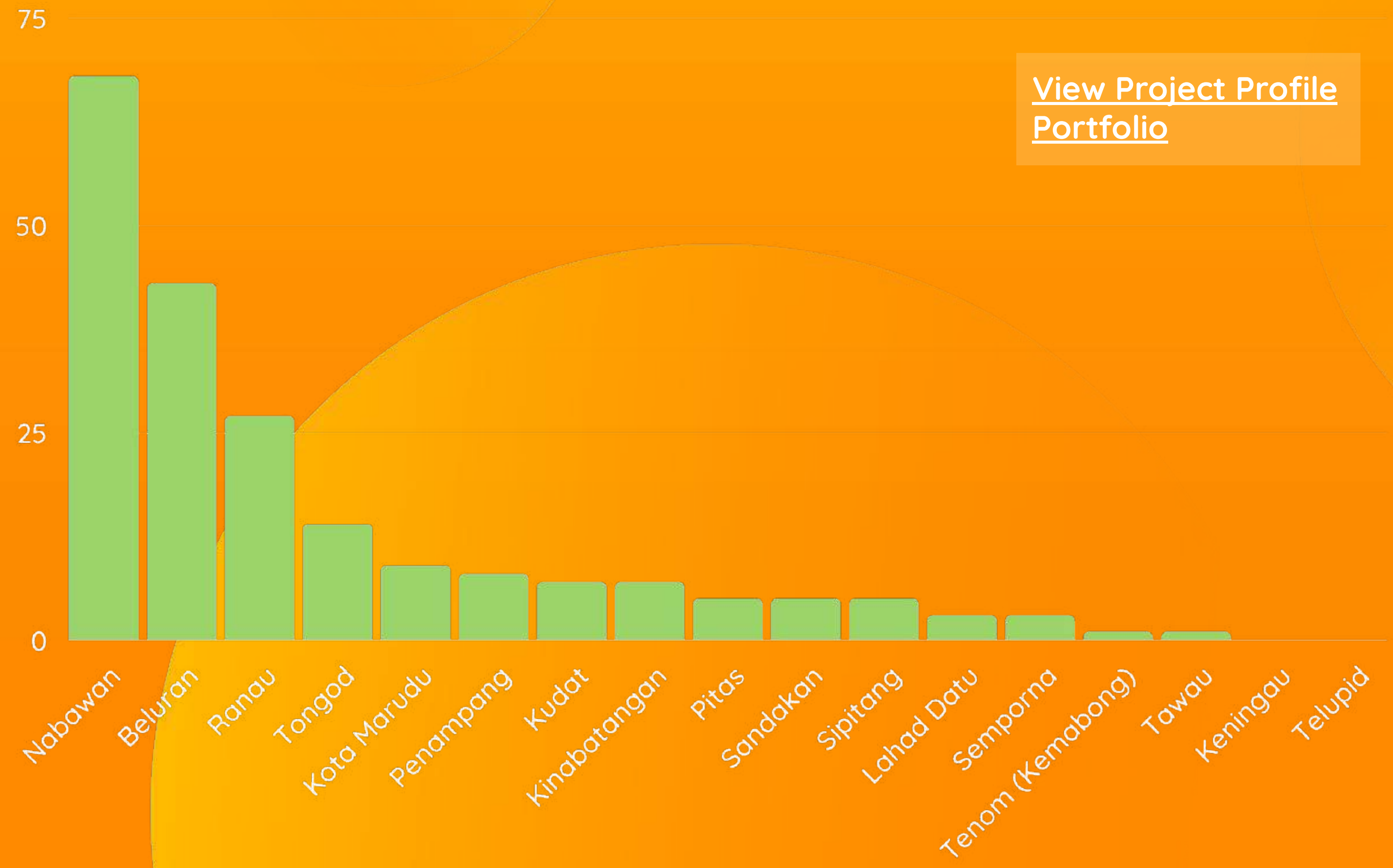
District	No.Un-electrified Villages
Nabawan	123
Beluran	78
Ranau	38
Tongod	34
Pitas	21
Kudat	20
Lahad Datu	19
Kota Marudu	14
Kinabatangan	12
Penampang	10
Sandakan	9
Semporna	8
Sipitang	5
Tenom (Kemabong)	4
Keningau	2
Tawau	2
Telupid	1
Total	400



206 Profiles of villages without access to grid electricity with approximate total population of 60,000

View Full Map

Numbers of Un-Electrified Villages by District Total in Project Profile Portfolio - 206 with approximate population of 60,000



[View Project Profile Portfolio]

District	No.Un-electrified Villages (206)	% Representation
Nabawan	68	55%
Beluran	43	55%
Ranau	27	71%
Tongod	14	41%
Kota Marudu	9	64%
Penampang	8	80%
Kudat	7	35%
Kinabatangan	7	58%
Pitas	5	24%
Sandakan	5	56%
Sipitang	5	100%
Lahad Datu	3	16%
Semporna	3	38%
Tenom (Kemabong)	1	25%
Tawau	1	50%
Keningau	0	0%
Telupid	0	0%
Total	206	52%

Profile: Kg. Wakaku, Ranau

Community Background	
Accessibility:	Accessible to any vehicle, about 1 hour 30 minutes from nearest town, telecommunication and internet access available
Population:	135 people, 31 households
Main income:	Working in private sector, farming, business, forest resources, government aid
Community leaders/groups:	Village Head, Village Development and Security Committee (JPKK)
Level of community organization:	Community meetings conducted regularly and when needed, last community activity less than a year ago (maintenance of village and public amenities/facilities)
Public buildings:	Place of worship, agricultural processing centre, sundry shop
Key natural resources:	Forest (fuel, food, medicine), river (water, food)
Key challenges:	clean water supply, land included in Forest Reserve class 2
Status of Electricity	
Sources of electricity:	Generator (individual), solar PV (individual)
Duration of electricity available:	About 6-12 hours a day, 7 days a week
Estimated cost of electricity per month:	RM250-396
Current uses of electricity:	Washing machine, lighting, TV, telephone charging, fan
Productive end use potential:	Refrigeration (fish & game), agricultural products processing (chili), online marketing

Profile: Kg. Bongon (Kecil), Sandakan

Community Background	
Accessibility:	Requires change in mode of transport from car to boat, about 20 minutes away from nearest town, telecommunication and internet access available
Population:	270 people, 60 households
Main income:	Working in private sector, fishing
Community leaders/groups:	Village Head, Village Development and Security Committee (JPKK), Youth Group, Women's Group
Level of community organization:	Only village representative makes decisions, last community activity between 1-2 years ago (maintenance of village & public amenities)
Public buildings:	School, place of worship, sundry shop
Key natural resources:	Sea (food)
Key challenges:	Telecommunication service, part of village included in forest reserve
Status of Electricity	
Sources of electricity:	Generator (individual)
Duration of electricity available:	About 6-7 hours a day
Estimated cost of electricity per month:	RM250-300
Current uses of electricity:	Lighting, telephone charging, TV, fan, washing machine
Productive end use potential:	Freezer, refrigeration (fish & seafood)

Profile: Kg. Sonsogon Magandai, Kota Marudu

Community Background	
Accessibility:	Only accessible via 4WD, about 66km away from nearest town, no telecommunication and internet access available
Population:	644 people, 243 households
Main income:	Farming
Community leaders/groups:	Village Head, Village Development and Security Committee (JPKK), The People's Volunteer Corps (RELA), Religious Body
Level of community organization:	Community meetings conducted when needed, last community activity less than a year ago (communal agricultural activities, maintenance of village and public amenities)
Public buildings:	Kindergarten, place of worship, community hall
Key natural resources:	Forest (fuel, food, handicraft, medicine), river (water, food)
Key challenges:	Lack of telecommunication, Poor road condition, encroachment by logging company, river pollution by logging, land ownership
Status of Electricity	
Sources of electricity:	Solar PV (individual)
Duration of electricity available:	About 4-24 hours a day, 7 days a week
Estimated cost of electricity per month:	RM0-15
Current uses of electricity:	Lighting, telephone & walkie talkie charging
Productive end use potential:	Refrigeration, carpentry & building, tailoring

FEASIBILITY STUDIES

View Feasibility Studies

KAMPUNG SIZE

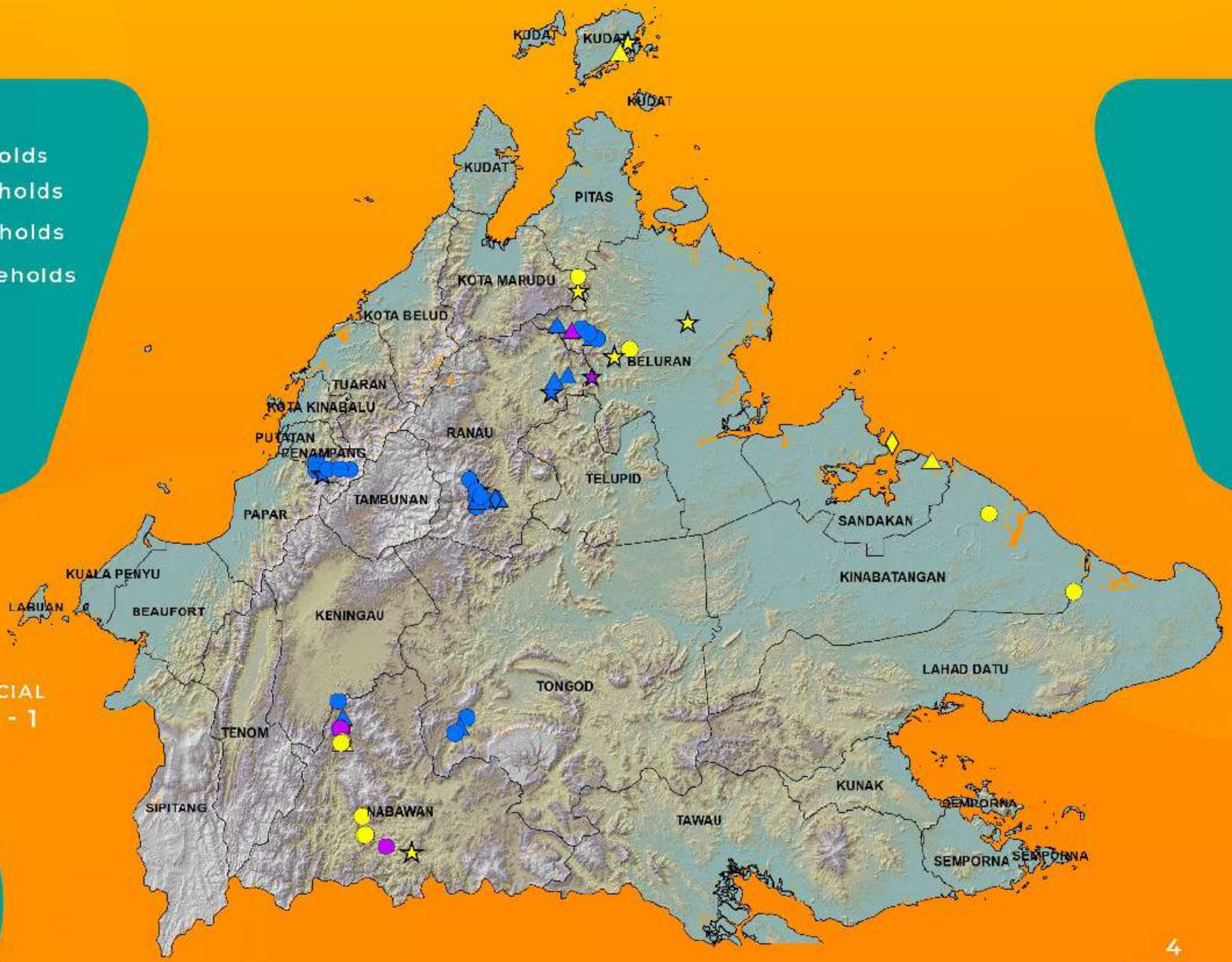
- 4-23 Households
- 24-47 Households
- 48-95 Households
- 96-326 Households

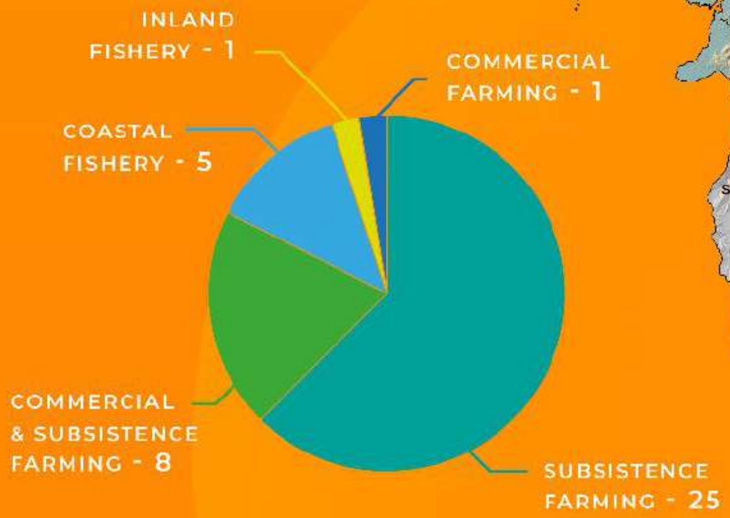
- 4-23 Households
- 24-47 Households
- 48-95 Households
- 96-326 Households

- 4-23 Households
- 24-47 Households
- 48-95 Households

LEGEND

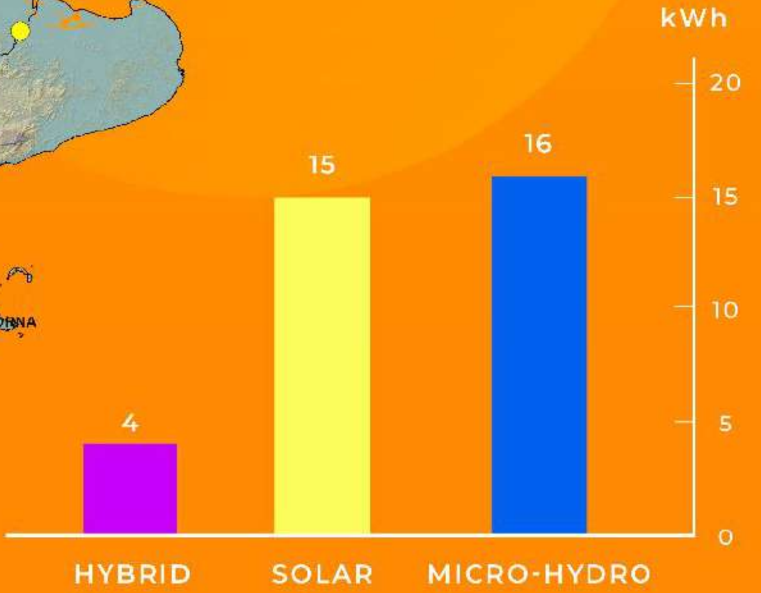
- Solar
- Solar
- Solar
- Solar
- Micro-hydro
- Micro-hydro
- Micro-hydro
- Micro-hydro
- Solar-hydro hybrid
- Solar-hydro hybrid
- Solar-hydro hybrid





57 VILLAGES & 35 SYSTEMS

APPROXIMATE POPULATION OF 13,049



Feasibility Studies

Village Name	District	Population	Livelihood	System	Size/Capacity (Potential)	Estimated cost (USD)
Terian	Penampang	370	Subsistence farming	Micro-hydro	25	$527,205.00
Tiku	Penampang	218	Subsistence farming	Micro-hydro	36	$426,832.00
Pongobonon	Penampang	200	Subsistence farming	Micro-hydro	11	$241,766.00
Longkogungan	Penampang	174	Subsistence farming	Micro-hydro	12	$241,766.00
Buayan	Penampang	323	Subsistence farming	Micro-hydro	N/A	
Kalanggaan	Penampang	65	Subsistence farming	Micro-hydro	27	$378,930.00
Susui	Tongod	57	Subsistence farming	Micro-hydro	35	$426,832.00
Kawayoi (Sub-village:Kuom)	Tongod	190	Subsistence farming	Micro-hydro	N/A	
Tambunan 2	Tongod	36	Subsistence farming	Micro-hydro	25	$378,930.00
Abuan 1 & 2	Beluran (Paitan)	850	Subsistence farming	Micro-hydro	1	$75,786.00
Waigon 1 & 2	Beluran (Paitan)	757	Subsistence farming	Micro-hydro	5	$120,883.00
Mangkasulap	Beluran (Paitan)	300	Subsistence farming	Micro-hydro	5	$120,883.00
Walou/Pinulango	Ranau	140	Commercial farming	Micro-hydro	89	$609,760.00
Wakaku	Ranau	135	Subsistence farming	Micro-hydro	18	$421,764.00
Paus/Pakolo	Ranau	50	Subsistence farming	Micro-hydro	20	$303,144.00
Tinanom + Botun	Ranau	256	Subsistence farming	Micro-hydro	16	$316,323.00
Kigiwit + Barambang + Kodop Baru + Mindahu	Ranau	596	Subsistence farming	Micro-hydro	N/A	
Patau/Tokokodo	Ranau	360	Commercial & subsistence farming	Micro-hydro	10	$241,766.00
Tundingon	Ranau	355	Subsistence farming	Micro-hydro	3	$120,883.00
Pamaitan	Ranau	230	Subsistence farming	Micro-hydro	3.5	$120,883.00
Katalirus (sub-village: Matur)	Nabawan(Pagalungan)	264	Subsistence farming	Micro-hydro	13	$362,649.00
Tagapalang	Beluran (Paitan)	460	Commercial & subsistence farming	Hybrid	10	$103,380.00
Monopod	Beluran (Paitan)	150	Subsistence farming	Hybrid	20	$206,760.00
Buntung	Nabawan(Pagalungan)	130	Inland fishery	Hybrid	10	$103,380.00
Ponontomon (sub-villages: Kalabi (S.Kalabi), Penarakan dan Katapu	Nabawan (Pagalungan)	308	Subsistence farming	Hybrid	20	$206,760.00
Sasandukon	Nabawan(Pagalungan)	280	Commercial & subsistence farming	Solar	25	$562,500.00
Siwalor/Sumab	Nabawan(Pagalungan)	162	Commercial & subsistence farming	Solar	10	$225,000.00
Lampas Sabinait	Nabawan(Pensiangan)	80	Commercial & subsistence farming	Solar	10	$225,000.00
Layon A, B, C	Nabawan (Pagalungan)	395	Subsistence farming	Solar	20	$450,000.00
Linayukan	Beluran (Paitan)	208	Commercial & subsistence farming	Solar	25	$562,500.00
Dampiron 2	Beluran (Paitan)	68	Commercial & subsistence farming	Solar	25	$562,500.00
Atog	Beluran (Paitan)	218	Commercial & subsistence farming	Solar	20	$675,000.00
Salangan	Kudat (Banggi)	120	Costal fishery	Solar	20	$450,000.00
Tambising	Kudat (Banggi)	105	Subsistence farming	Solar	10	$225,000.00
Pulau Berhala	Sandakan	2123	Costal fishery	Solar	10	$225,000.00
Bongon	Sandakan	270	Costal fishery	Solar	50	
Pitas Laut	Kinabatangan	117	Costal fishery	Solar	10	$225,000.00
Dagat	Kinabatangan	243	Costal fishery	Solar	10	$225,000.00
Sonsogon Magandai	Kota Marudu	644	Subsistence farming	Solar	20	$450,000.00
Sonsogon Suyad	Kota Marudu	300	Subsistence farming	Solar	20	$450,000.00

FS 30: Kg. Dagat, Kinabatangan

Community Background	
Accessibility:	Requires change in mode of transport from car to boat, about 3 hours away from nearest town, telecommunication and internet access available
Population:	243 people, 20 households
Main income:	Fishing, working in private sector or public sector, farming, business, government aid
Community leaders/groups:	Village Head, Village Development and Security Committee (JPKK), Youth Group, Women's Group, The People's Volunteer Corps (RELA), Religious Body, Association
Level of community organization:	Community meetings conducted regularly, last community activity less than a year ago (construction of public facilities, communal agricultural activities, maintenance of village & public amenities)
Public buildings:	Place of worship
Key natural resources:	Forest (fuel, food, medicine, handicraft), river (food), sea (food)
Key challenges:	Poor road condition, encroachment by outsiders in river and sea, river pollution, very near to forest reserve (unclear boundaries and conflict with wildlife), land ownership
Status of Electricity	
Sources of electricity:	Generator (village, generator (individual), solar PV (village)
Duration of electricity available:	About 4-6 hours a day
Estimated cost of electricity per month:	RM30-1700
Current uses of electricity:	Lighting, telephone & walkie talkie charging, fridge, rice cooker, washing machine, TV, karaoke, fan, torchlight charging
Productive end use potential:	Refrigeration (fish & seafood), make own ice, tourism

- **Population size:** 243, No of houses: 20
- **Type of settlement:** Linear
- Solar potential
- Average solar radiation per year: 99.33%
- Land status and size of solar site: Village reserve (18 x 9 m)
- Proposed to have 1 solar system

FS 22: Kg. Walou, Ranau

Community Background	
Accessibility:	Accessible to any vehicle, about 70 km away from nearest town, telecommunication available but no internet access
Population:	140 people, 42 households
Main income:	Commercial farming
Community leaders/groups:	Women's Group, Peoples' Organization, Village Development and Security Committee (JPKK), Religious Body
Level of community organization:	Community meetings conducted regularly and when needed, last community activity less than a year ago (construction of public facilities)
Public buildings:	Place of worship, sundry shop, community hall
Key natural resources:	River (food), forest (food & handicraft)
Key challenges:	Telecommunication service, construction of roads cause existing micro-hydro to be moved
Status of Electricity	
Sources of electricity:	Generator (individual), solar PV (individual)
Duration of electricity available:	Less than 4 hours a day
Estimated cost of electricity per month:	RM150
Current uses of electricity:	Lighting, telephone charging
Productive end use potential:	Grinder, sundry shop, food processing for agriculture, refrigeration

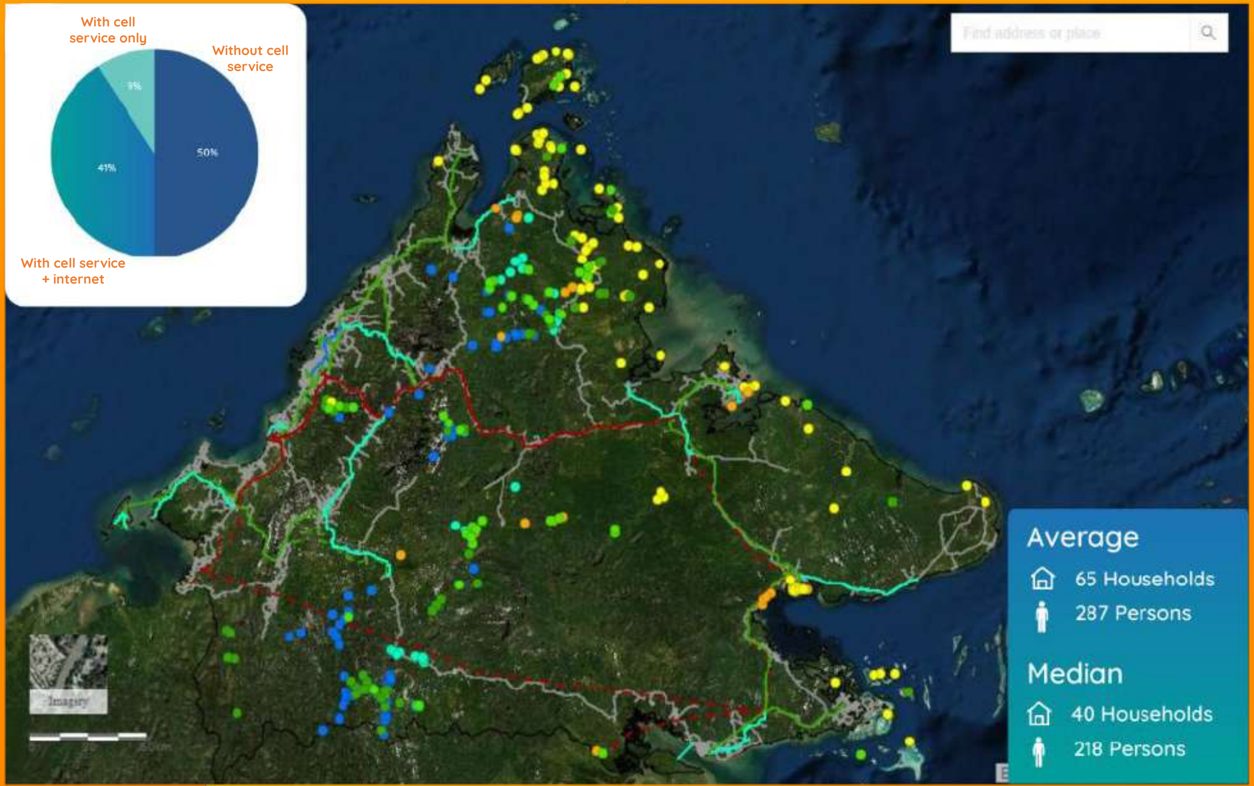
- Population size: 440, No of houses: 54
- Type of settlement: Linear and clustered Sub-villages: Pinulangon, Tembialon and Deromomol
- Micro-hydro potential (Sungai Walou)
- Potential power 89.4 kW (Head: 15.3 m, Flow: 0.965)
- Issues:
  - Existing micro-hydro project under Light-Up Borneo (only up to Deromomol area) was not enough to power the whole village and frequent power disruption causes damage to electrical appliances

FS 4: Kg. Monopod, Paitan, Beluran

Community Background	
Accessibility:	Requires change in mode of transport from car to boat, about 3 hours away from nearest town, telecommunication and internet access available
Population:	150 people, 52 households
Main income:	Subsistence farming, working in private sector, government aid
Community leaders/groups:	Village Development and Security Committee (JPKK), Religious Body, Peoples' Organization, Farmer's Association, Youth Group
Level of community organization:	Only village representative makes decisions, no recent community activity in last 5 years
Public buildings:	School, place of worship, sundry shop
Key natural resources:	Forest (building materials, food), river (water, food)
Key challenges:	Logging, encroachment and river pollution (pesticide) by oil palm plantation affects water catchment and clean water supply
Status of Electricity	
Sources of electricity:	Solar PV (individual), generator (individual)
Duration of electricity available:	About 4-7 hours a day, 7 days a week
Estimated cost of electricity per month:	RM37-150
Current uses of electricity:	Lighting, telephone charging
Productive end use potential:	Building tools (wood planer, compressor), sundry shop (fridge/freezer), keep food longer

- Population size: 150, No of houses: 69
- Type of settlement: Linear
- Solar-micro-hydro hybrid potential
- Average solar radiation per year: 77.5%
- Land status and size of solar site: Personal grant (18 x 9 m)
- Potential hydro power at Sungai Kumonsi 2.7 kW (Head: 36 m, Flow: 0.012)
- Proposed to install 1 solar and 1 micro-hydro system

Understanding Sabah's Un-Electrified Villages



TERRITORIES & ECOLOGY

Most are in isolated forested regions where villagers combine multiple livelihoods often living along rivers. A second cluster are within mangroves, on islands and in other isolated coastal regions where fisheries dominate. Traditional lands and ways of life are threatened, and communities divided about sustainability & long-term strategies

CULTURAL VALUES

Collective identity remains strong: "We practice communal labour in most of our activities such as farming, building repairs and celebrations." – Kg. Terian, Penampang

INTERSECTING ISSUES

Un-electrified villages also typically face water problems, and for cooking half access gas cylinders and half use firewood: opportunities for integrated solutions

FINANCIALLY POOR

8 of the 10 poorest districts in Malaysia are in Sabah: 71% of the project portfolio's villages are in these very districts.

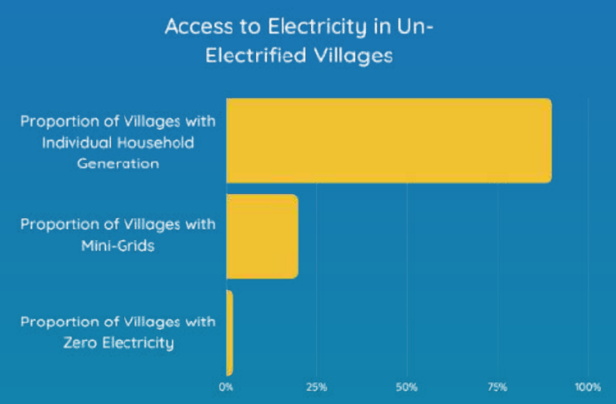
PHYSICALLY ISOLATED

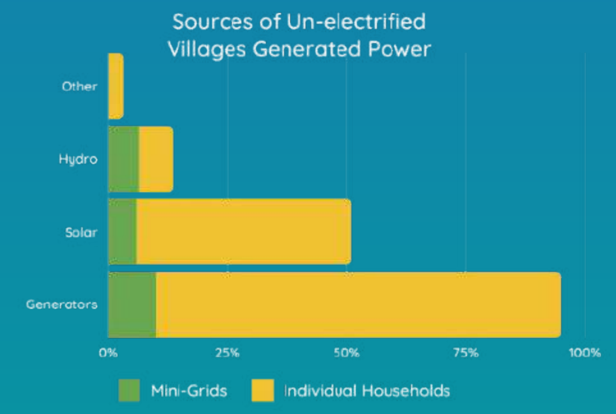
Far from sealed roads, commercial centres & nearly half reliant on boats for access.

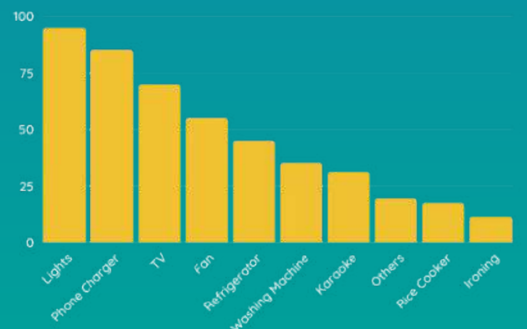
PARTIALLY ABANDONED

Poor services mean 60% of villages experience seasonal abandonment (average of 8.6 households absent 6 months/year) and some whole villages are 'fallow'.

Current Electrical Access and Use in Sabah’s Un-Electrified Villages







Most “Un-Electrified” villages have some access, however, it is mostly non-renewable, very expensive, and available only a few hours a day.

ACCESS TO ELECTRICITY

- 98% of villages have some Electricity – made up of basic mini-grids & individual household systems.
- The most commonly used are diesel generators, of which there were an average of 15.7/village & 89% of villages have at least one personal generator.
- However, these systems do not reach all villagers & have numerous operational problems.

HIGH COST

Due to the high cost transporting diesel over long distances using bad roads or boats, average lighting & electricity generation costs RM200 - RM300 per month.

RELIABILITY

The situation varies widely across both villages and individual villagers, along a continuum between zero supply and continuous electricity of insufficient quality & expensive. Assessed against the ESMAP (World Bank) Multi Tier Framework they are at Tiers 0 to 3, whereas need and aspiration seek tiers 4 to 5.

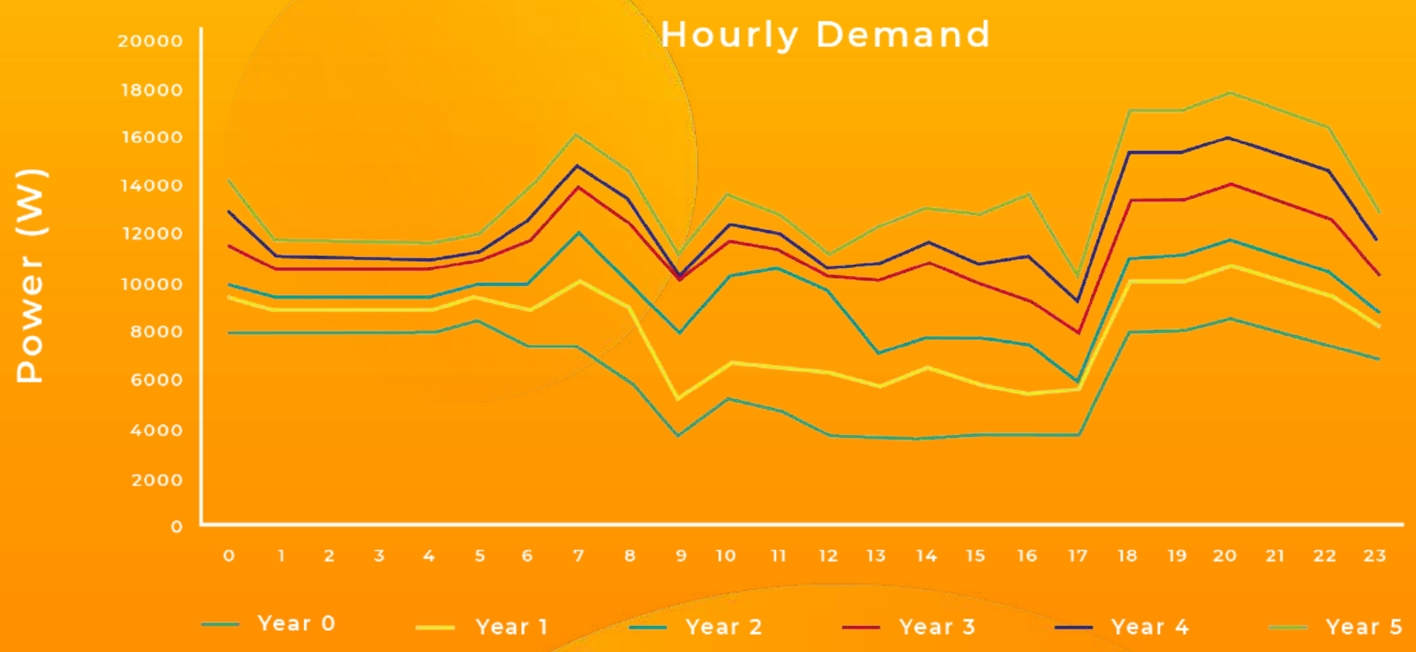
INSTITUTIONS

- 80% have churches or mosques, only half with electricity.
- 30% have schools and 9% have clinics – nearly all depending on diesel or diesel-solar hybrids.
- 43% have sundry shops, most un-electrified.
- 14% have agri-processing facilities, mostly un-electrified.

LOW AVAILABILITY FOR MOST

- On a given day 23-53% of villages report they have 4 hours of power or less and 60-86% have six hours of power or less; only 2% reported routinely 24 hour access.
- This is due to high diesel expense & the use of lower tier renewable energy systems.
- Most villages reported interruptions in supply daily, weekly or monthly.
- Many current systems also cannot support high energy appliances e.g. refrigeration.

A Future with Mini-Grids



FORECASTING NEEDS & GROWTH:

Calculations of daily demand level and flux suggests only mini-grids can meet current needs, let alone anticipate future demand for most villages: indeed we estimate demand will double over 8 years.

DEVELOPING & MANAGING MINI-GRIDS:

- Communities identified a variety of existing village level community organisations with the capacity to implement and manage mini-grids alongside local government agencies.
- 40% of communities pointed to village religious institutions, 10% pointed to women's groups and 10% to youth groups.
- Few villages believed they lacked institutions that could do this.

LOCAL BUSINESS OPPORTUNITIES:

- 56% of villages described ongoing business activities that would immediately benefit from electrification.
- Fridges & freezers were identified as key for both sundry shop development but also for cold storage for local products (including fish).
- Opportunities with electrification are homestays (ecotourism), restaurants, agri-processing, print shops, etc.
- Hands-on support for developing village enterprise could go hand-in-hand with technical support for electrical supply systems.

ANCHOR CLIENTS:

- One third of the villages have government facilities (schools & clinics) currently paying heavily for diesel generation with unreliable supply.
- 10% have agri-processing facilities that could be anchor clients.
- Telecommunications towers exist – or should exist – in most locations.
- Most villages have places of worship relying on expensive diesel gensets.

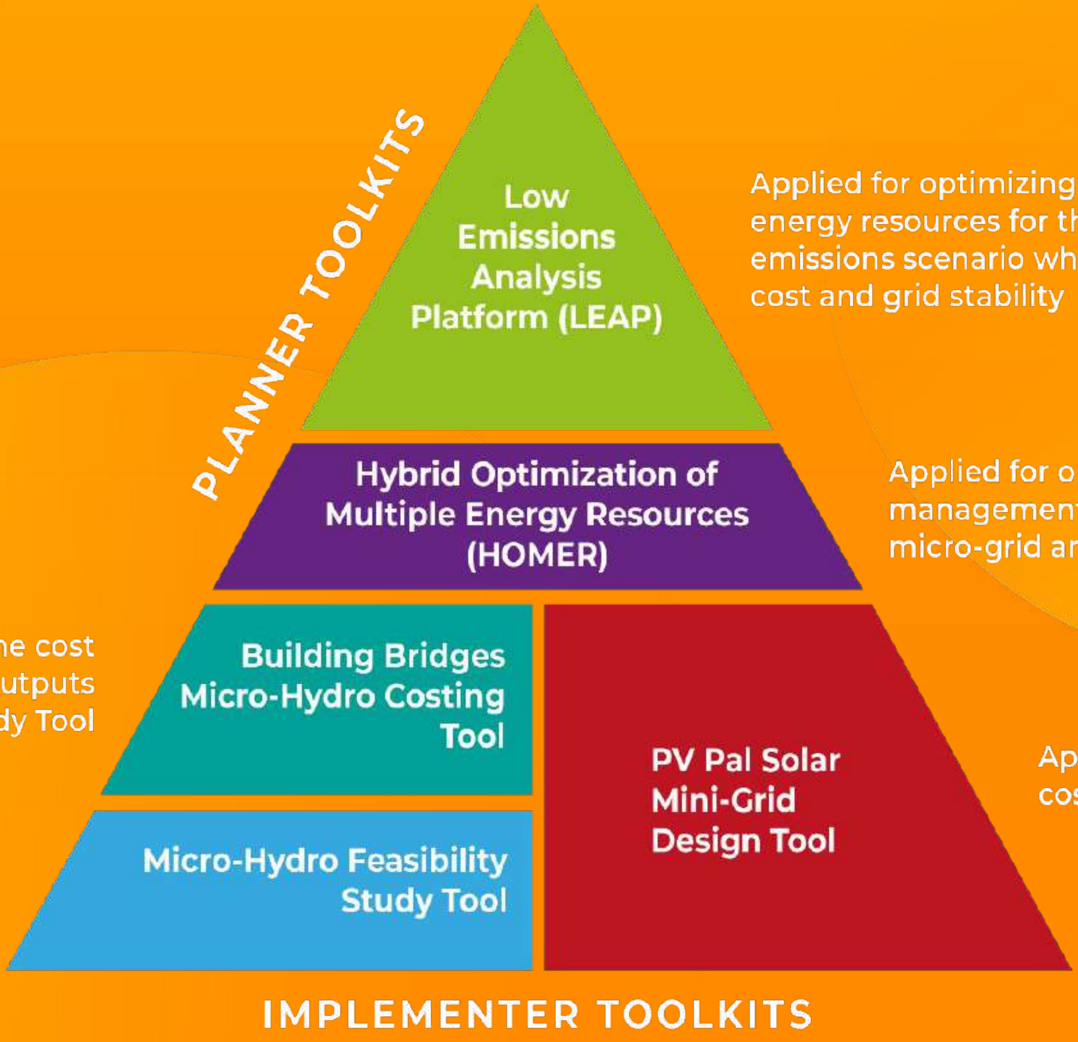
CAN PAY, WILL PAY:

- Willingness to pay for electricity, on a scale of 1-10, where 5 is the SESB rate; the most common response was 9 and the mean 8.29.
- Levelized Cost of Energy calculations suggest micro-hydro at RM0.90 & solar at RM2.78 per kWh, well below SESB grid connection rates.
- With 50% installation support we can be commercially viable at less cost than villagers currently pay for intermittent mostly non-renewable supplies (SESB tariffs is perhaps 80% subsidized).

DOMESTIC EXPRESSED NEEDS:

- Need for electricity for lights & phones is universal.
- 36% named need for fridges & mini-grids must support this for food handling & comfort.
- TVs and fans are sought by most, and a third want karaoke machines.
- Remote villages appear to afford these appliance purchases.

Mini-Grid Systems: Planner & Implementer Toolkits (Methodology)



Applied for optimizing configuration of energy resources for the lowest emissions scenario while considering cost and grid stability

Applied for optimizing cost, load management and reliability of hybrid micro-grid and grid-connected systems

Applied to analyze and determine the cost of micro-hydro systems based on outputs from the Micro-Hydro Feasibility Study Tool

Applied to analyze and determine both cost and size of solar PV mini-grids

Applied to analyze micro-hydro data from the field and determine potential energy capacity in kilowatts

View Planner & Implementer Toolkits

Multi-Tier Framework for Measuring Access to Electricity

ATTRIBUTES		TIER 0	TIER 1	TIER 2	TIER 3[b]	TIER 4	TIER 5
Capacity	Power capacity ratings (W or daily Wh)	Less than 3 W	At least 3 W	At least 50 W	At least 200 W	At least 800 W	At least 2 kW
		Less than 12 Wh	At least 12 Wh	At least 200 Wh	At least 1 kWh	At least 3.4 kWh	At least 8.2 kWh
	Services		Lighting of 1,000 lmhr per day	Electrical lighting, air circulation television, and phone charging are possible			
Availability[a]	Daily Availability	Less than 4 hours	At least 4 hours		At least 8 hours	At least 16 hours	At least 23 hours
	Evening Availability	Less than 1 hours	At least 1 hours	At least 2 hours	At least 3 hours	At least 4 hours	
Reliability		More than 14 disruptions per week			At most 14 disruptions per week or At most 3 disruptions per week with a total duration of more than 2 hours"	(> 3 to 14 disruptions/week or ≤ 3 disruptions/week with > 2 hours of outage	At most 3 disruptions per week with a total duration of less than 2 hours
Quality		Household experiences voltage problems that damage appliances				Voltage problems do not affect the use of desired appliances	
Affordability		Cost of a standard consumption package of 365 kWh per year is more than 5% of household income			Cost of a standard consumption package of 365 kWh per year is less than 5% of household income		
Formality		No bill payments made for the use of electricity				Bill is paid to the utility, prepaid card seller, or authorized representative	
Health and Safety		Serious or fatal accidents due to electricity connection				Absence of past accidents	

Source: World Bank ESMAP, 2015

Minimum Requirements by Tier of Electricity Access

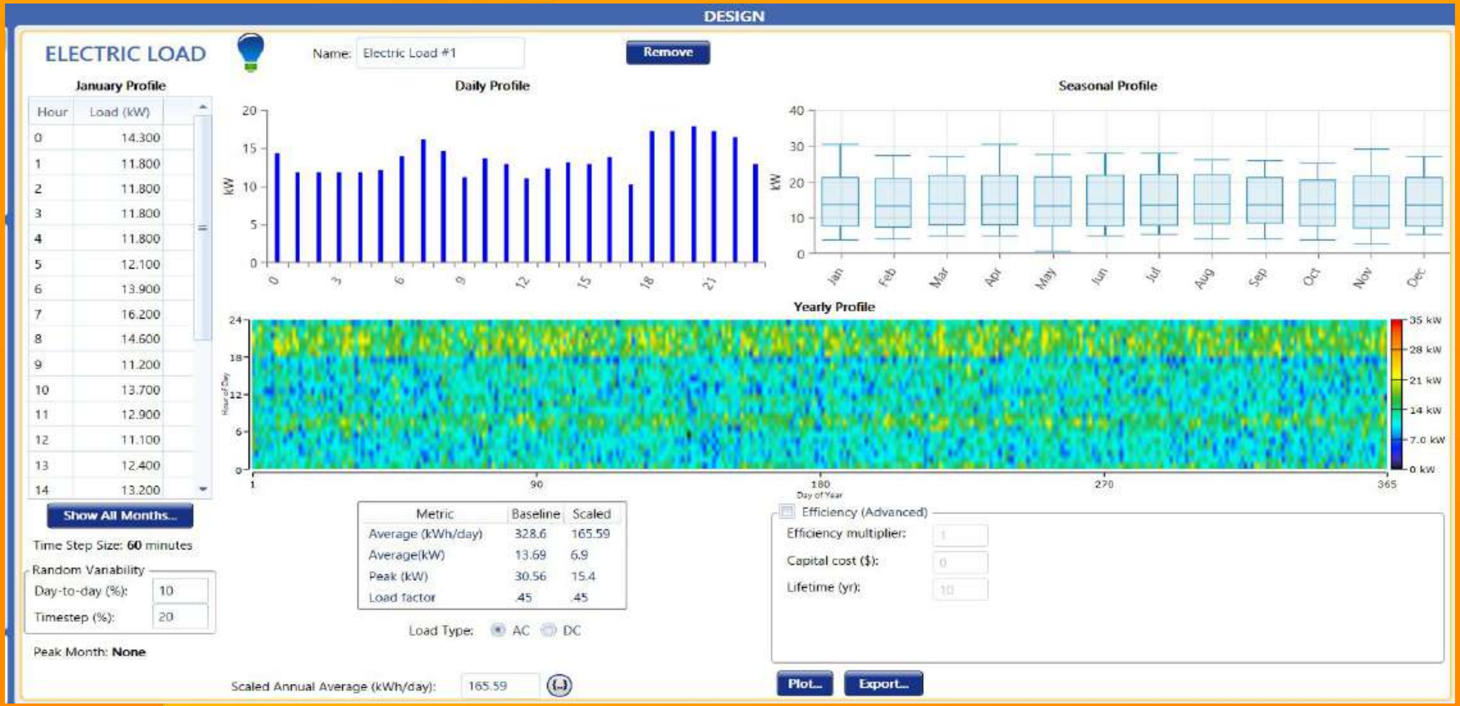
TIER 0	TIER 1	TIER 2
Electricity is not available or is available for less than 4 hours per day (or less than 1 hour per evening). Households cope with the situation by using candles, kerosene lamps, or dry-cell-powered devices (flashlight or radio).	At least 4 hours of electricity per day is available (including at least 1 hour per evening), and capacity is sufficient to power task lighting and phone charging or a radio. Sources that can be used to meet these requirements include a SLS, a solar home system (SHS), a minigrid (a small-scale and isolated distribution network that provides electricity to local communities or a group of households), and the national grid.	At least 4 hours of electricity per day is available (including at least 2 hours per evening), and capacity is sufficient to power low-load appliances—such as multiple lights, a television, or a fan (see table 1)—as needed during that time, Sources that can be used to meet these requirements include rechargeable batteries, an SHS, a mini-grid, and the national grid.

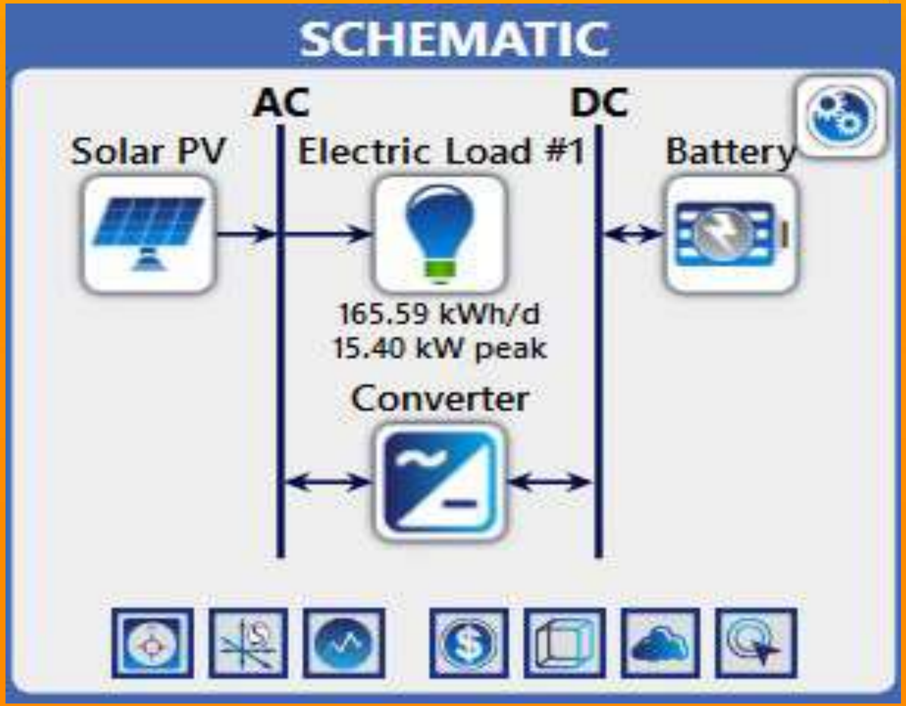
TIER 3	TIER 4	TIER 5
At least 8 hours of electricity per day is available (including at least 3 hours per evening), and capacity is sufficient to power medium-load appliances — such as refrigerator, freezer, food processor, water pump, rice cooker, or air cooler (see table 1) — as needed during that time. In addition, the household can afford a basic consumption package of 365kWh per year. Sources that can be used to meet these requirements include an SHS, a generator, a mini-grid, and the national grid.	At least 16 hours of electricity per day is available (including 4 hours per evening), and capacity is sufficient to power high-load appliances — such as a washing machine, iron, hair dryer, toaster, and microwave (see table 1) — as needed during that time. There are no frequent or long unscheduled interruptions, and the supply is safe. The grid connection is legal, and there are no voltage issues. Sources that can be used to meet these requirements include diesel-based mini-grids and the national grid.	At least 23 hours of electricity per day is available (including 4 hours per evening), and capacity is sufficient to power very high-load appliances — such as an air conditioner, space heater, vacuum cleaner, or electric cooker (see table 1) — as needed during that time. The most likely source.

Source: World Bank ESMAP, 2015

Mini-Grid Systems : Planner & Implementer Toolkits (Methodology)

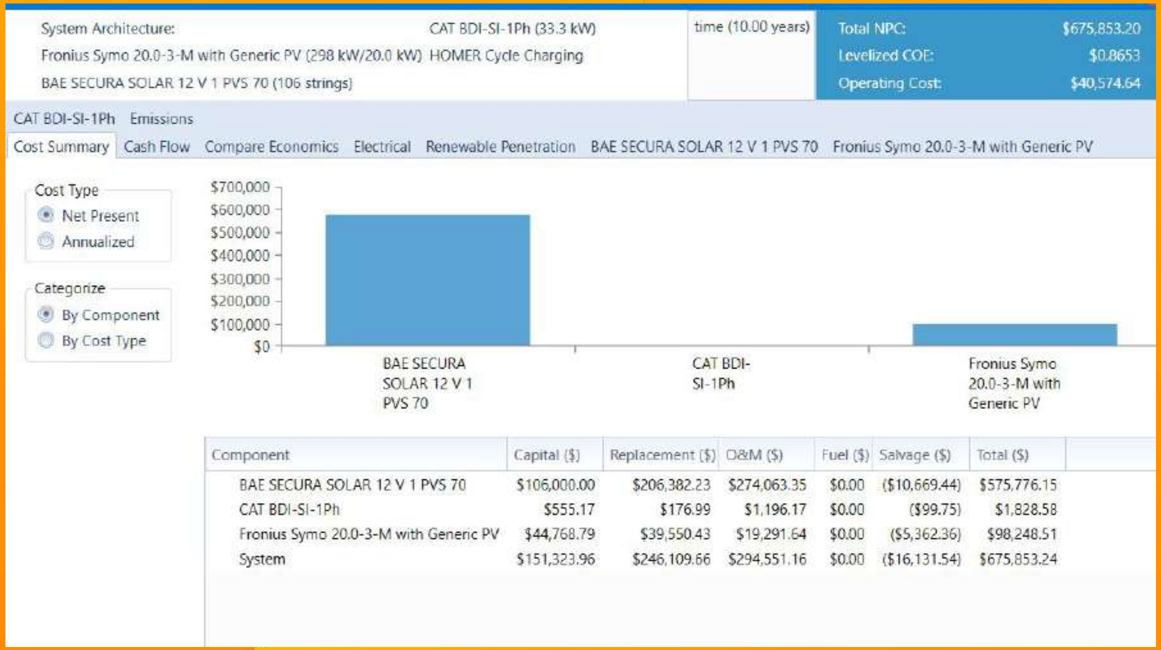
Example HOMER outputs based on dataset collected from 53 households in Kg Atog, Paitan sub-district





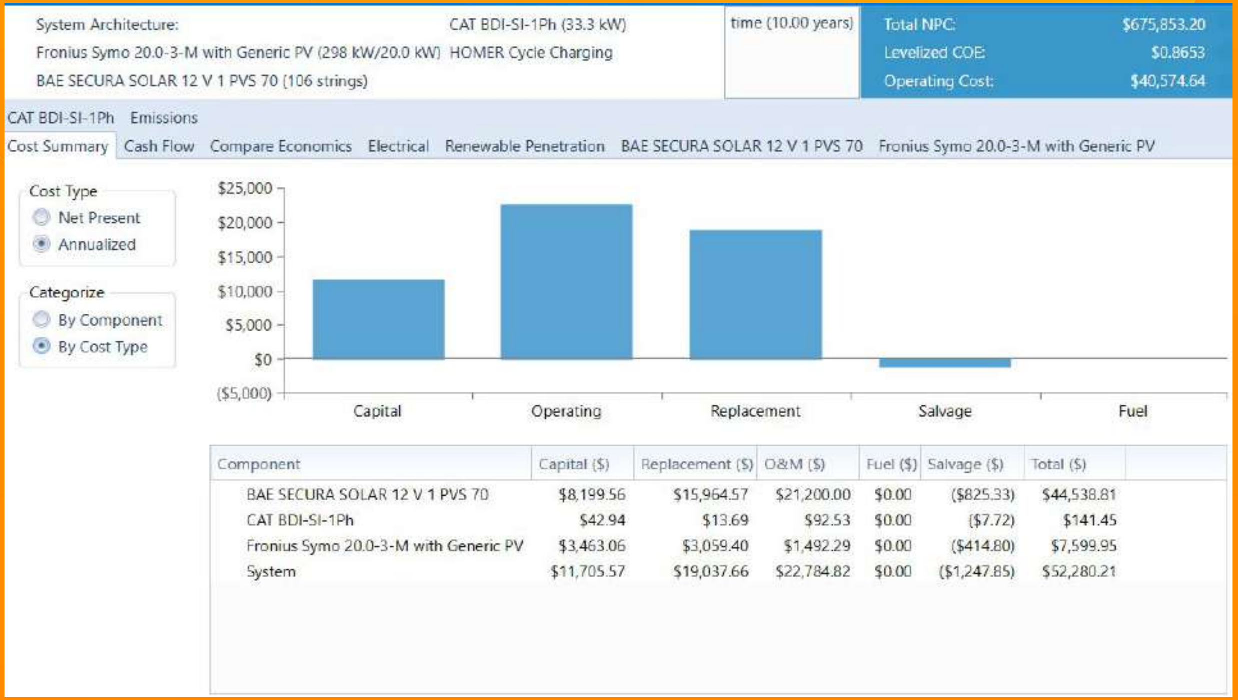
Combined with GE’s demand projection tool, HOMER optimizes the design of a mini-grid system based on lifetime costs, and anticipated loads throughout the day and annually, over a 10 year period.

Mini-Grid Systems: Planner & Implementer Toolkits (Methodology)



Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
BAE SECURA SOLAR 12 V 1 PVS 70	$106,000.00	$206,382.23	$274,063.35	$0.00	($10,669.44)	$575,776.15
CAT BDI-SI-1Ph	$555.17	$176.99	$1,196.17	$0.00	($99.75)	$1,828.58
Fronius Symo 20.0-3-M with Generic PV	$44,768.79	$39,550.43	$19,291.64	$0.00	($5,362.36)	$98,248.51
System	$151,323.96	$246,109.66	$294,551.16	$0.00	($16,131.54)	$675,853.24

HOMER was applied to estimate the cost of renewable energy deployment for 53 households of Kg Atog, Paitan sub-district, breaking costs down into the categories indicated below.



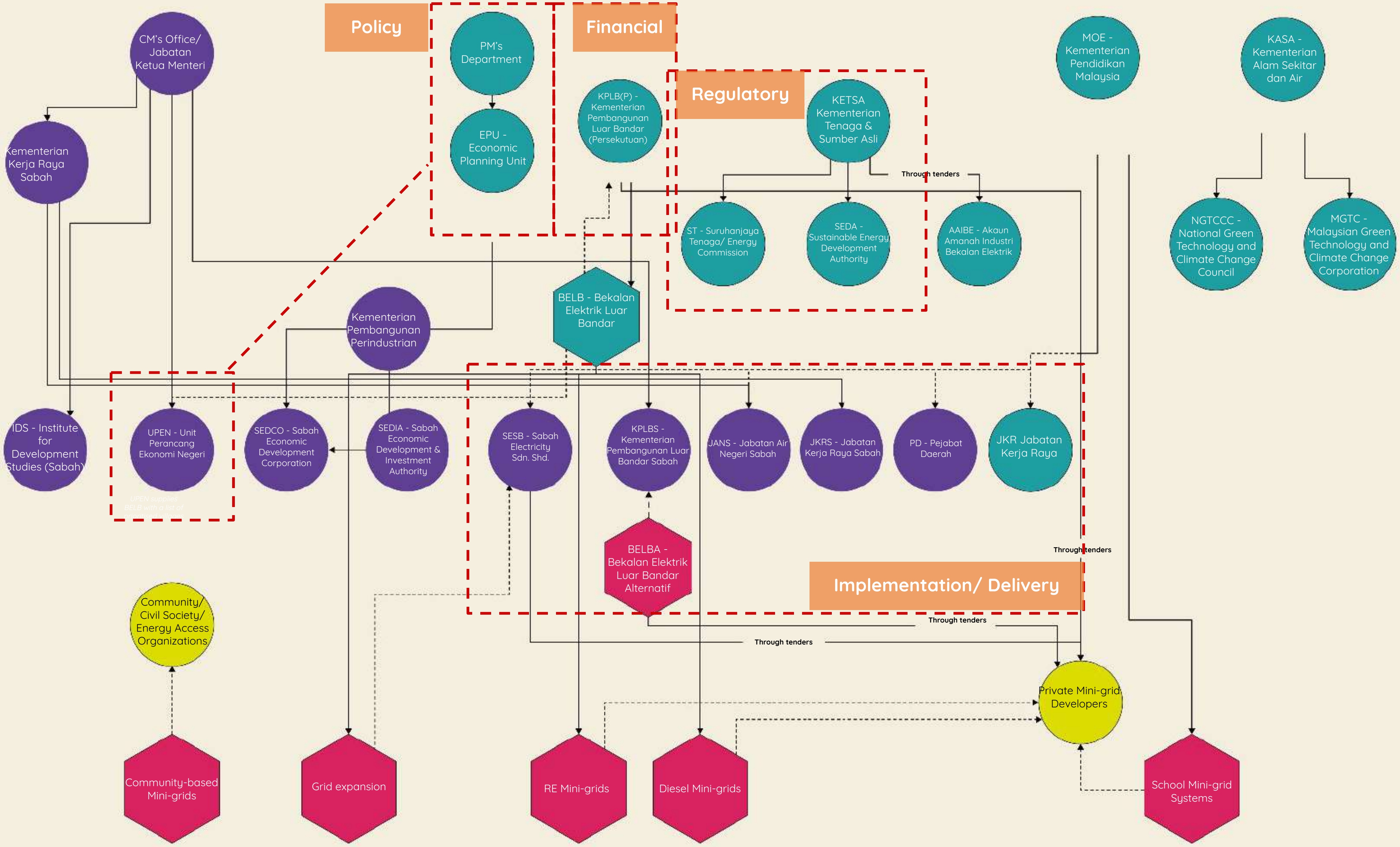
Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
BAE SECURA SOLAR 12 V 1 PVS 70	$8,199.56	$15,964.57	$21,200.00	$0.00	($825.33)	$44,538.81
CAT BDI-SI-1Ph	$42.94	$13.69	$92.53	$0.00	($7.72)	$141.45
Fronius Symo 20.0-3-M with Generic PV	$3,463.06	$3,059.40	$1,492.29	$0.00	($414.80)	$7,599.95
System	$11,705.57	$19,037.66	$22,784.82	$0.00	($1,247.85)	$52,280.21

The tool is also capable of optimizing the cost of a hybrid power system (i.e. combination of multiple systems or components), from utility-scale and distributed generation to standalone microgrids.

Existing rural electrification efforts in Malaysia:

Rural Electrification	Estimated Costs	Challenges/Shortcomings	Notes
Grid extension through BELB (Government rural electrification programme)	< RM100,000/household connection (budgeted limit)	Relies heavily on government energy policy Challenging terrain, particularly in the south, where generation capacity is low Relies on road access Not cost-effective for remote areas	First-choice (but not always least cost) strategy. Other options are only considered if costs exceed RM100,000/household (for Sabah. RM80,000/household for Peninsular Malaysia).
Off-grid mini-grids through BELB (Government rural electrification programme)	RM15,000 - 50,000/household for 20 - 100 households. Not included: Additional costs for transportation other than water and land.	Lack of local operations and maintenance know-how Focus is solely on delivering electricity connections	Costs are for solar hybrid systems. Systems deployed are a mix of technologies (e.g. diesel, solar, micro-hydro, solar hybrid).
Solar home systems through BELB (Government rural electrification programme)	*N/A. The World Bank estimates that good quality solar home systems cost between USD 200-400.*	Limiting in its ability to support productive end-uses of electricity Also relies on technical support network for maintenance, which currently does not exist	Only for extremely remote communities.
Sarawak's SARES program (State rural electrification programme)	RM55,000 - 65,000/household connection	So far dedicated to residential energy use only	For a daily 1kW, 3kWh per household systems. Mostly solar mini-grids, with some micro-hydro. Solar home systems for extremely remote and small communities.
Community-based/involved Mini-grids (Private/civil society initiatives)	RM30,000 - 65,000/household (based on technology, location)	May operate outside of safety and reliability standards or regulations	For systems between 5-30kW systems. Mostly micro-hydro, with some solar.

Stakeholder Policy Map



What policies could enable 100% rural electrification target?

BARRIERS	RECOMMENDATIONS	OUTCOMES & PROPOSED POLICIES
Electrification planning and coordination excludes communities & other potential actors	An updated rural electrification roadmap & targets, with multi-stakeholder input	• An equitable & just target of 100% by 2030 • Include (local) stakeholders (e.g. community-based organizations), feedback loops to ensure inclusion & reflect higher number of unelectrified (>400 communities) in planning • Include socio-economic, sustainability goals
Grid extension strategy is costly and slow for rural areas, and locally available resources are not fully taken into consideration	A least-cost approach to rural electrification that prioritises mini-grids	• Capitalise on mini-grids' potential for cost reductions: e.g. RM30,000-65,000/connection vs RM100,000/connection for grid extension, & lower LCOE over system lifetimes • Incorporate optimization modeling into planning activities
Insufficient investment and finance	Build out an efficient and transparent delivery model to attract investment	• Encourage private & international funding with an updated roadmap & improved programme delivery that derisks investment • Co-develop and demonstrate a transparent delivery model that can attract international investment, and comply with their standards • Incorporate financial incentives that encourage private sector investment in mini-grids and (productive end-use based) micro-enterprises

What policies could enable 100% rural electrification target?

BARRIERS	RECOMMENDATIONS	OUTCOMES & PROPOSED POLICIES
Current single owner system adds costly operational challenges, & does not consider other models	Move beyond connections towards integrated, impact & evidence-driven multi-stakeholder delivery	• Incorporate innovative business & delivery models, i.e. different combinations of ownership, financing, operational models & technology (based on local needs) • Include energy access practitioners & community-based organisations in delivery • Incorporate Productive Uses of Energy (PUE) & socio-economic opportunity in project planning
There is a high entry barrier for participation, and developers are not incentivized to build sustainable systems	Develop & clarify guidelines, streamline project implementation	• Formulate appropriate mini-grid guidelines that facilitate scale-up & reduce entry barrier for lower-tier mini-grids (i.e. under 72 kWp) 　○ Allow micro-utilities for rural, off-grid systems 　○ All licensing to go through state actors 　○ Clarify rules around EIA for micro-hydro 　○ Consider registration and not licensing • Streamline implementation to reduce barriers for delivery partners • Training and capacity building for ecosystem actors
Lack of guidelines and incentives to build sustainable systems risks systems being operated unsafely and unreliably	Develop and implement a quality assurance framework	• Develop a quality assurance framework to ensure health, safety & environment requirements are met • Avoid new standards & regulations with a high degree of specification that prevents a wide range of technical & delivery model flexibility • Ensure ongoing monitoring & evaluation to ensure system operations & sustainability

View Advancing Policies

Legal forms of community ownership:

Community Ownership Model

Co-operatives

Co-operatives are jointly owned by their members to achieve common economic, social or cultural goals based on the democratic principle of "one member, one vote". Co-operatives rely largely on volunteers but can have paid staff.

Partnerships

In partnerships, individual partners own shares in the community-ownership model. The key objective of a partnership is to generate profits for the shareholders, in addition to any other benefits of the project. Unlike co-operatives, partnerships may not operate on the basis of "one member, one vote". Nor do partnership firms rely largely on volunteers, as co-operatives do. They may employ full-time staff to provide expertise needed for specific projects.

Non-profit Organisations

A non-profit organisation is formed by investments from its members, who are responsible for financing the organisation but do not take back any profits. Profits are reinvested in projects focused on community development.

Community Trust

Trusts use the returns from investment in community projects for specific local purposes. These benefits are also shared with people who are not able to invest directly in projects.

Housing Associations

A form of non-profit, such association offer housing to low-income families and individuals.

Mini-Grid Operational Models:

1 Utility

Pros:
- Experienced, with more capacity
- Usually more established

Cons:
- Governed by political agenda
- Market-driven (low rural electrification priority)

2 Private

Pros:
- May have better operational/ management capacity
- Incentivised to promote financial viability

Cons:
- Lack of financial support

3 Community

- Co-operatives
- Community-owned management committee
- Housing associations

Pros:
- Buy-in/Sense of ownership
- Reduces bureaucracy

Cons:
- Lack of technical skills
- Governance and social conflicts

4 Hybrid

Pros:
- Opportunity to combine different strengths and advantages

Cons:
- Inclusion of multiple entities could increase (transaction) costs
- Need to balance different interests

How can we accelerate rural electrification to these communities?

Now that we understand the need and the potential solutions, **how do we support the local energy access sector** and **how to we ensure that these projects meet the immediate and long-term needs of rural Sabahans?**

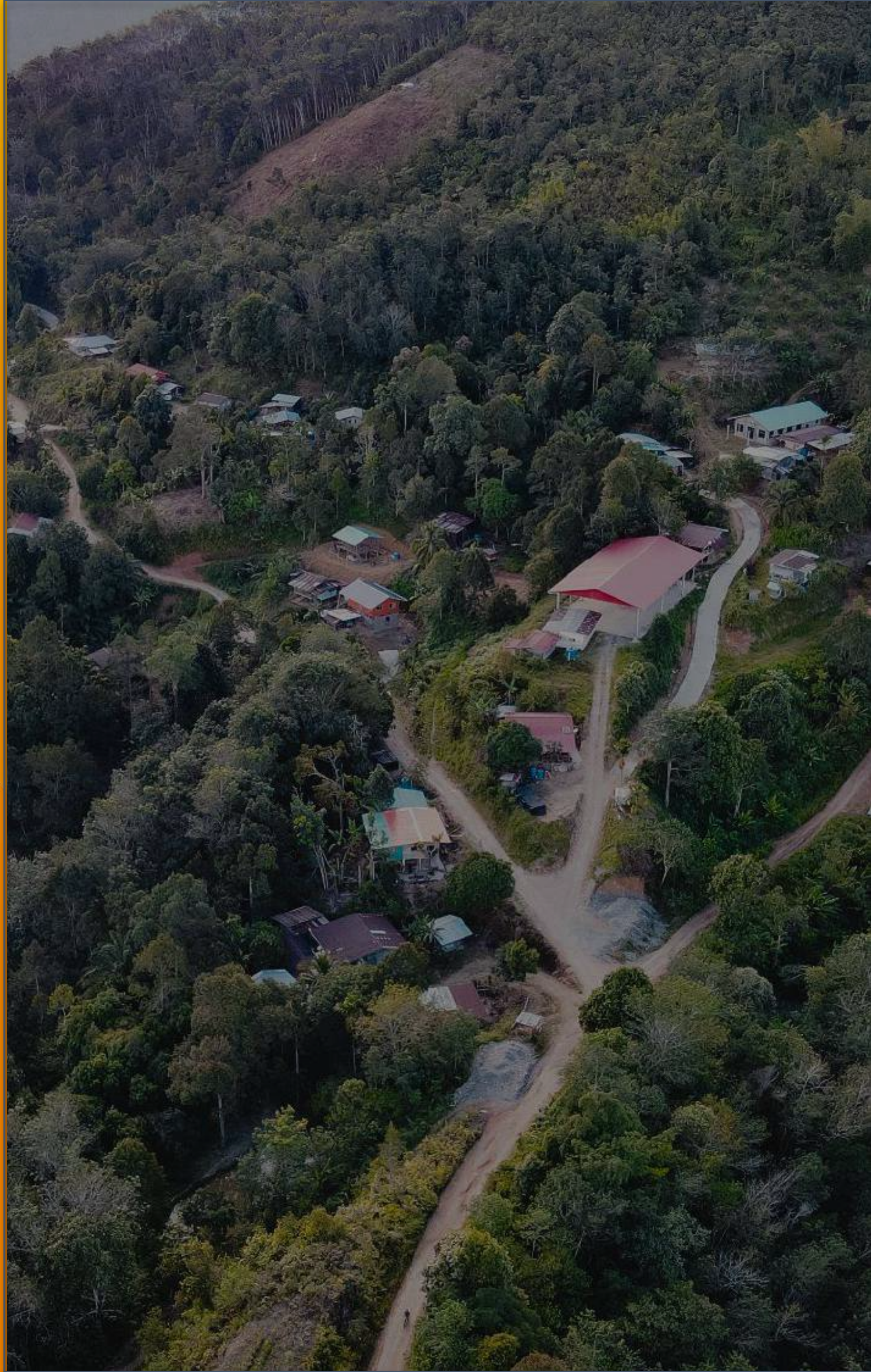
We need a strategic intervention in Sabah's renewable energy sector to **accelerate the funding, prioritization and deployment** of off-grid renewable energy installations.

We need to enable an **ecosystem where the public sector, financiers, civil society, community stakeholders, and community-based partner organizations** work together in harmony.

Communities need to be **engaged to ensure ownership, participation, and accountability** of the projects.

Must be cost effective - less than BELB programs and designed to sustained sufficient quantity (kwH/HH) and maintenance of system over time.

The proposed "program" efficiently and transparently **manages available funds and channels them to the people who need them** – the rural communities and those that can best help communities meet those needs.



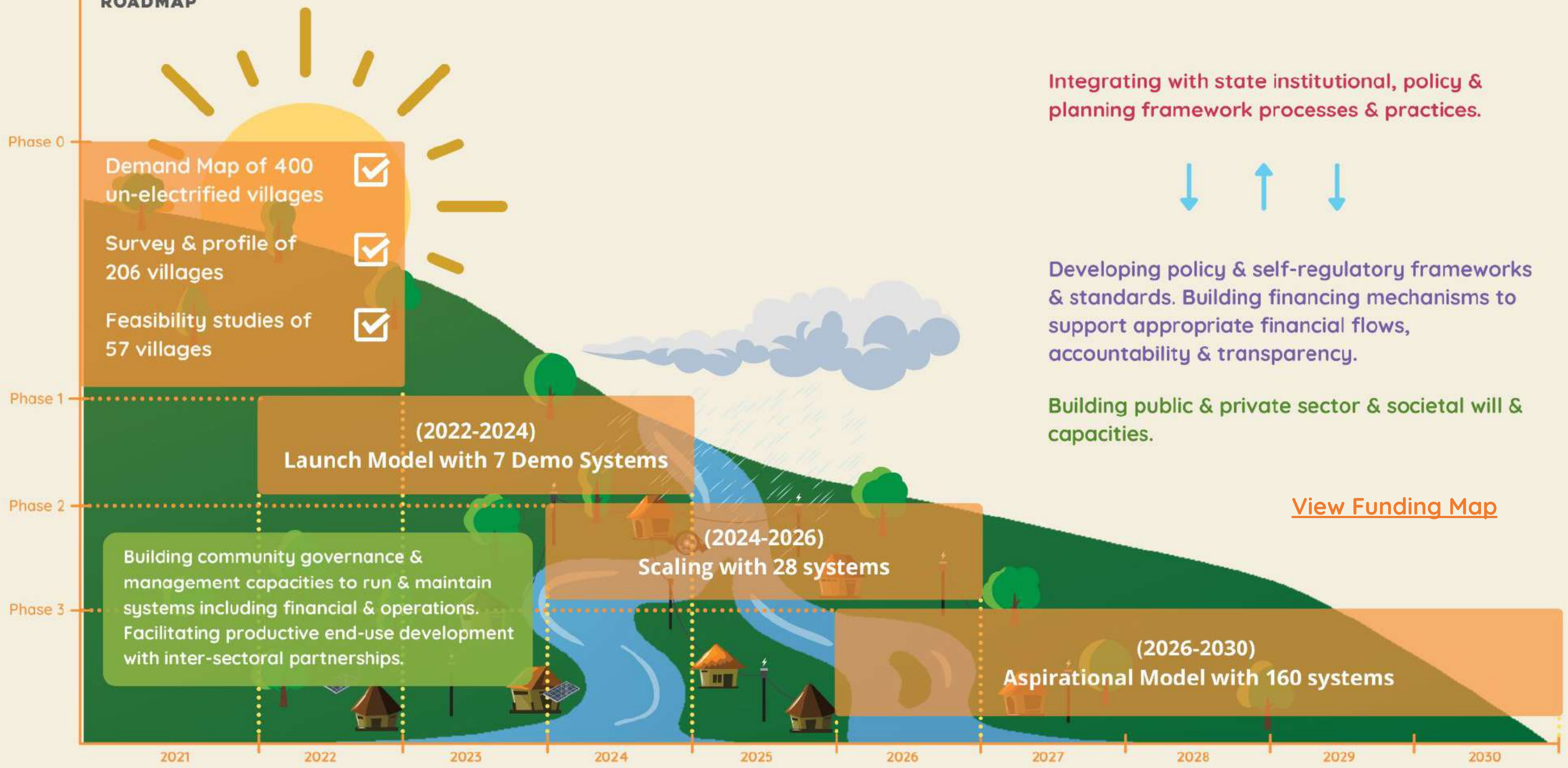
Launch Model

Goal: demonstrate that this is a cost-effective, socially responsible, sustainable model to fund, execute rural electrification at an accelerated pace.

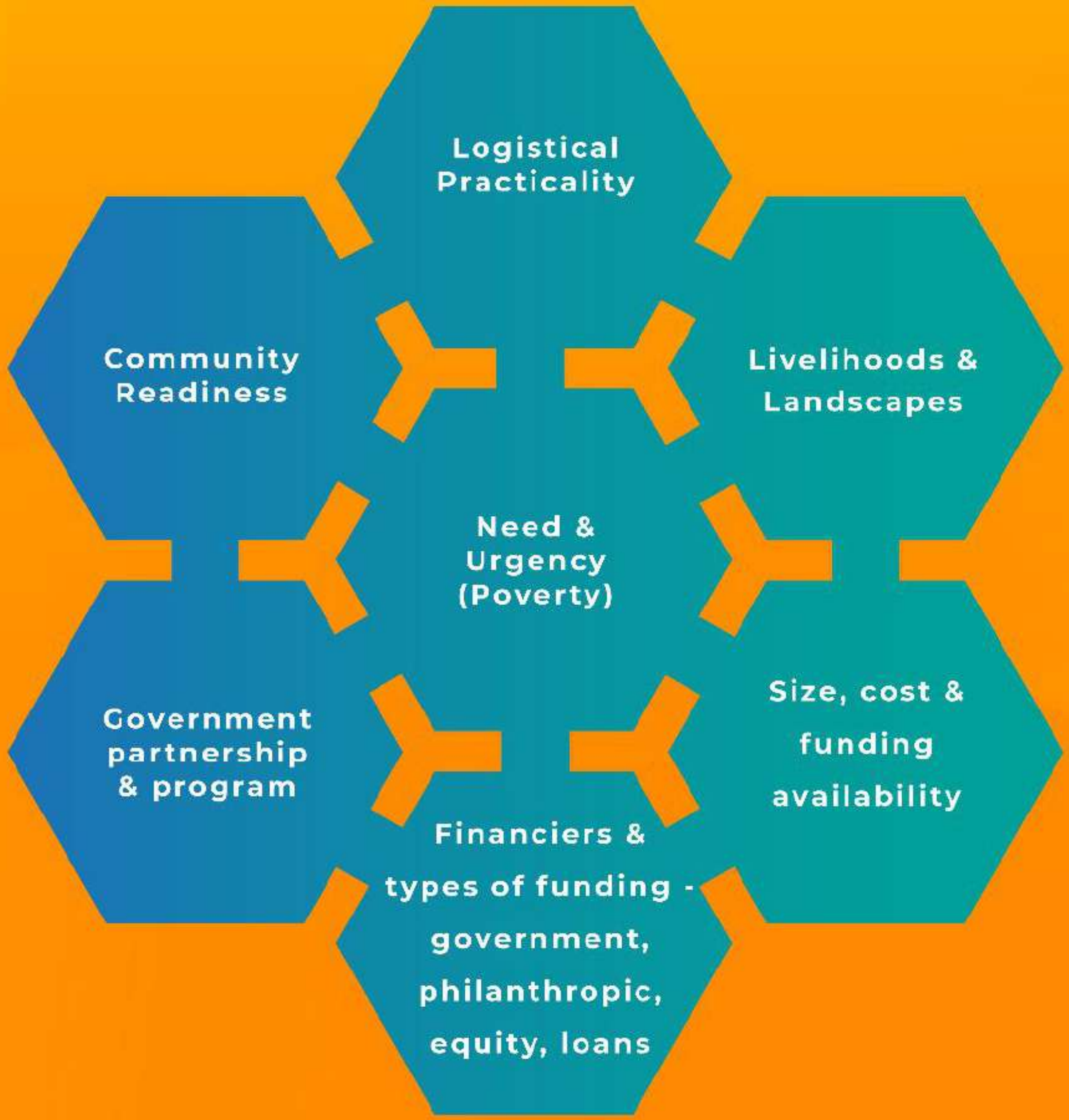
Aspirational Model

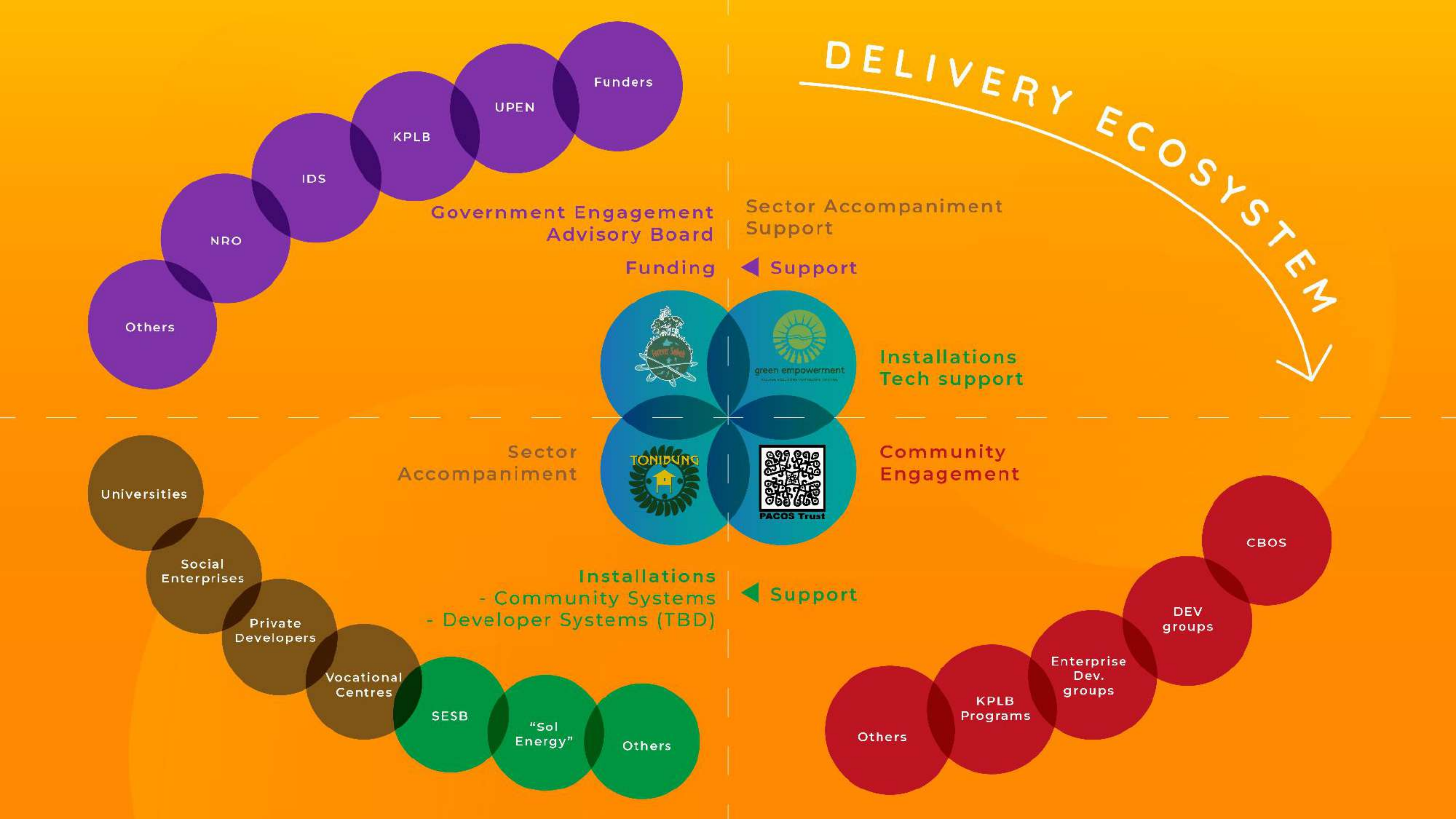
Goal: Based on a proven track record with technically successful and financially viable mini-grids in earlier phases, the program becomes an independently-operating initiative with an electrification fund and a self-sustaining business model that can achieve 100% electrification for Sabah's rural communities.

Flow Chart of Roadmap Rollout



Selection Criteria




DELIVERY ECOSYSTEM
Funders
UPEN
KPLB
IDS
NRO
Others
Government Engagement
Advisory Board
Funding
Sector Accompaniment
Support
Support
green empowerment
TONIBUNG
PACOS Trust
Installations
Tech support
Sector
Accompaniment
Community
Engagement
Universities
Social
Enterprises
Private
Developers
Vocational
Centres
SESB
"Sol
Energy"
Others
Installations
- Community Systems
- Developer Systems (TBD)
Support
CBOS
DEV
groups
Enterprise
Dev.
groups
KPLB
Programs
Others

Phased Rollout & Funding

PHASE 1

(2022-2024):

Launch Model with 7 Demo Systems

USD5,000,000

Philanthropic grants
Government programs
Private Funding (e.g. CSR)

PHASE 2

(2024-2026):

Scaling with 28 Systems

USD15,000,000

Philanthropic grants
Government programs (incl. loan guarantees)
Private funding (e.g. equity)
Impact Investment
Loans - direct, subsidized interest, etc.
Climate/ESG funding

PHASE 3

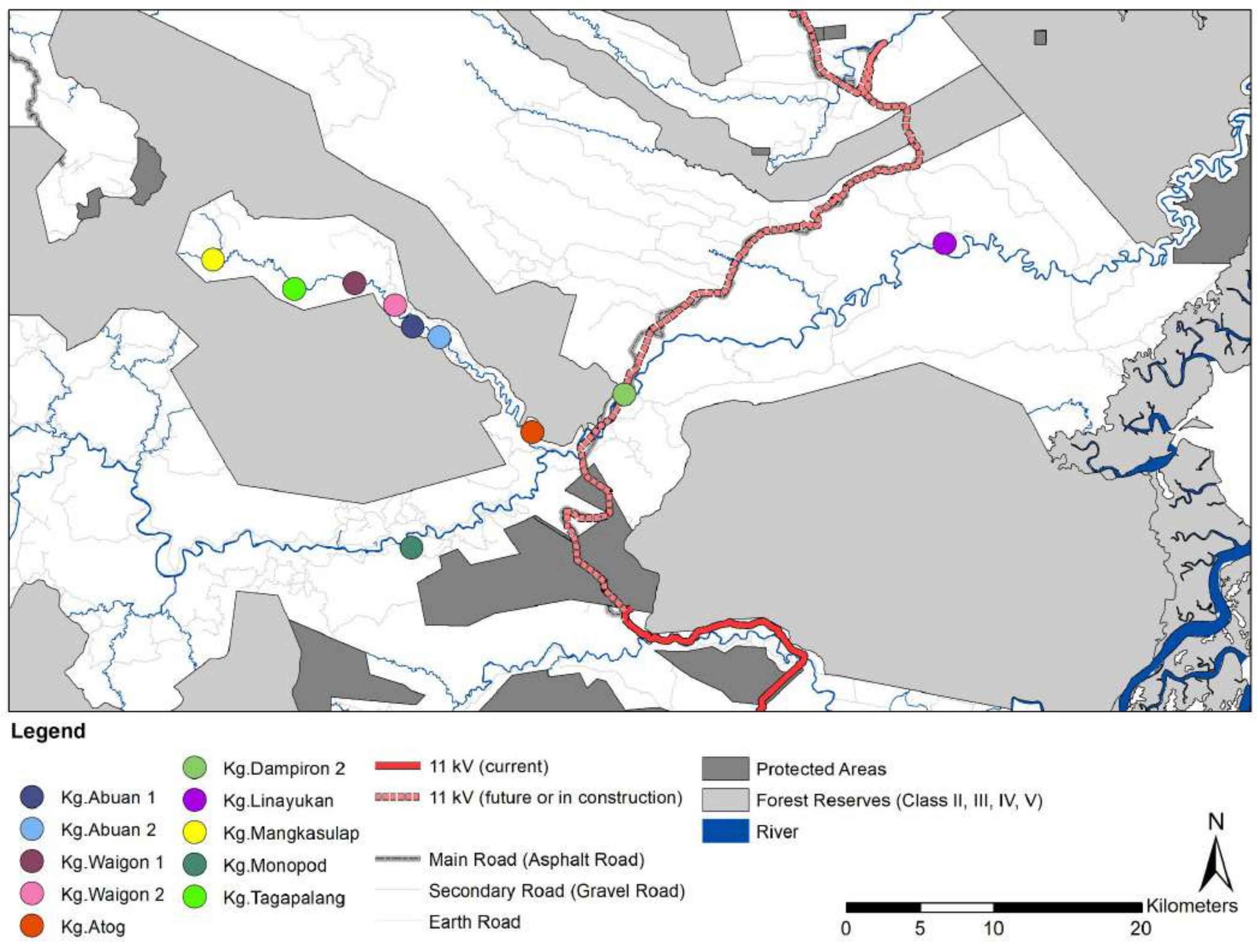
(2026-2030):

Aspirational Model with 160 Systems

USD60,000,000

Philanthropic grants
Government programs (incl. loan guarantees)
Private funding (e.g. equity)
Impact Investment
Loans - direct, subsidized interest, etc.
Climate/ESG funding

Phase 1 Sample: 2022 to 2024 - Paitan (Beluran)



Key Aims

- 7 mini-grids completed
- 5 new contracting companies trained to work on mini-grids
- 5 productive end-use business plans developed
- Pilot regulatory & quality assurance framework and roll-out
- 160 mini-grid feasibility studies completed

RE Output Targeted

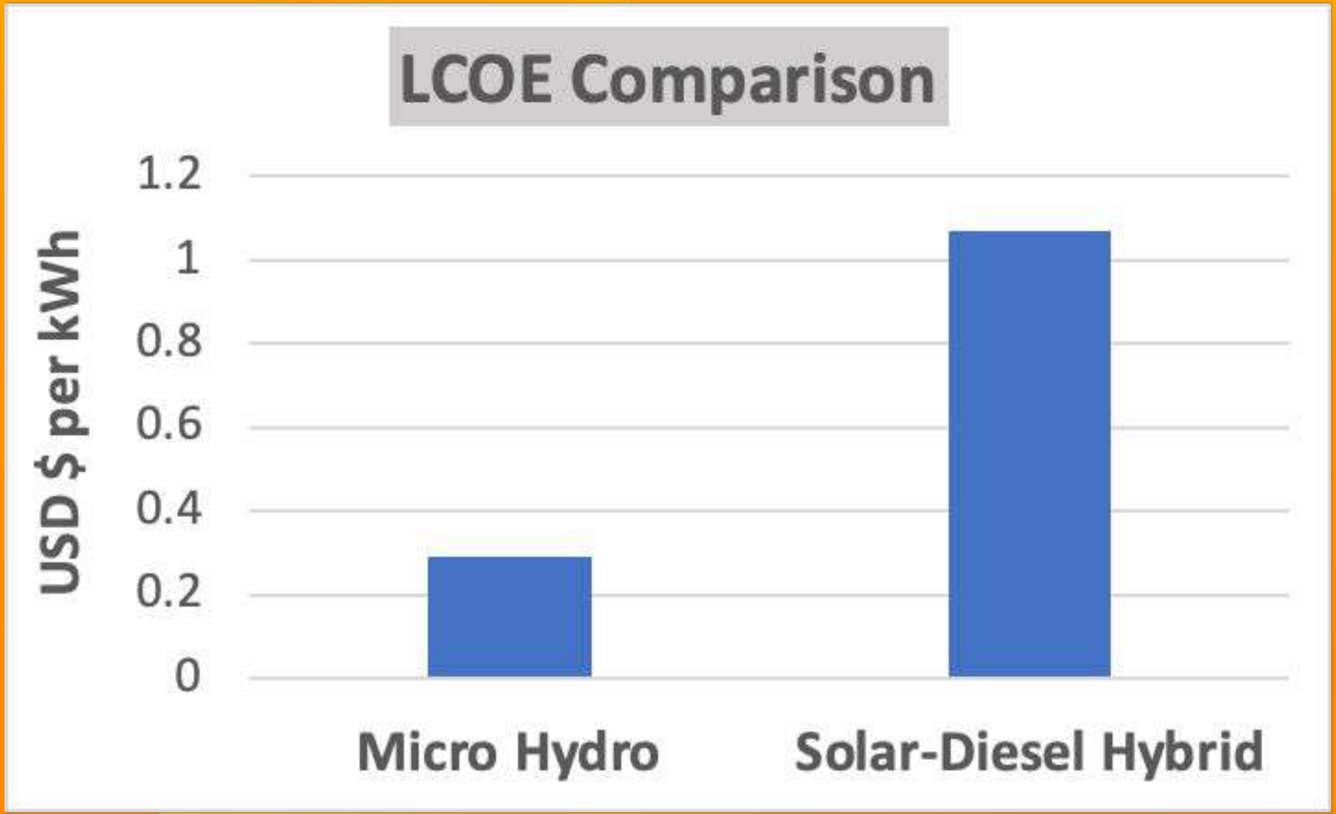
- 120 kW

Estimated Cost

- $5,000,000

The 10 kampungs in Paitan, a sub-district of Beluran, were selected for discussion as an important accessible cluster, along a single river system to simplify logistics and collaborative training in one of the poorest districts of Sabah. 7 are in RMK12; due to high potential for Micro-Hydro Power, we studied and present a comparison. Possible candidate district for Phase 1 is Tongod.

Phase 1 continued: Comparing Generation Sources in Kg. Abuan and Kg. Waigon



While some of these villages are covered in the RMK12, it may be worth considering the fully renewable, mini-grid alternative once we look at the data. A micro-hydro system of this size could feasibly also be interconnected to the main grid when/if it arrives.

System Parameters

- The feasibility study team identified a potential mini-hydro power resource in this cluster that could potentially power 4 villages (Abuan 1 & 2, as well as Waigon 1 & 2).
- Using GE's demand projection tool, demand has been estimated to peak at 48kW in 10 years.

Results Generated

- The system has been optimized and designed for peak demand at 50kW, but has an estimated potential power generation capacity of > 100kW.
- When we analyze the LCOE for this system, and compare them with our LCOE figures for the alternatives, we can see a compelling case emerge for the micro-hydro system.

Phase 1 continued: the Case for Implementation in Paitan

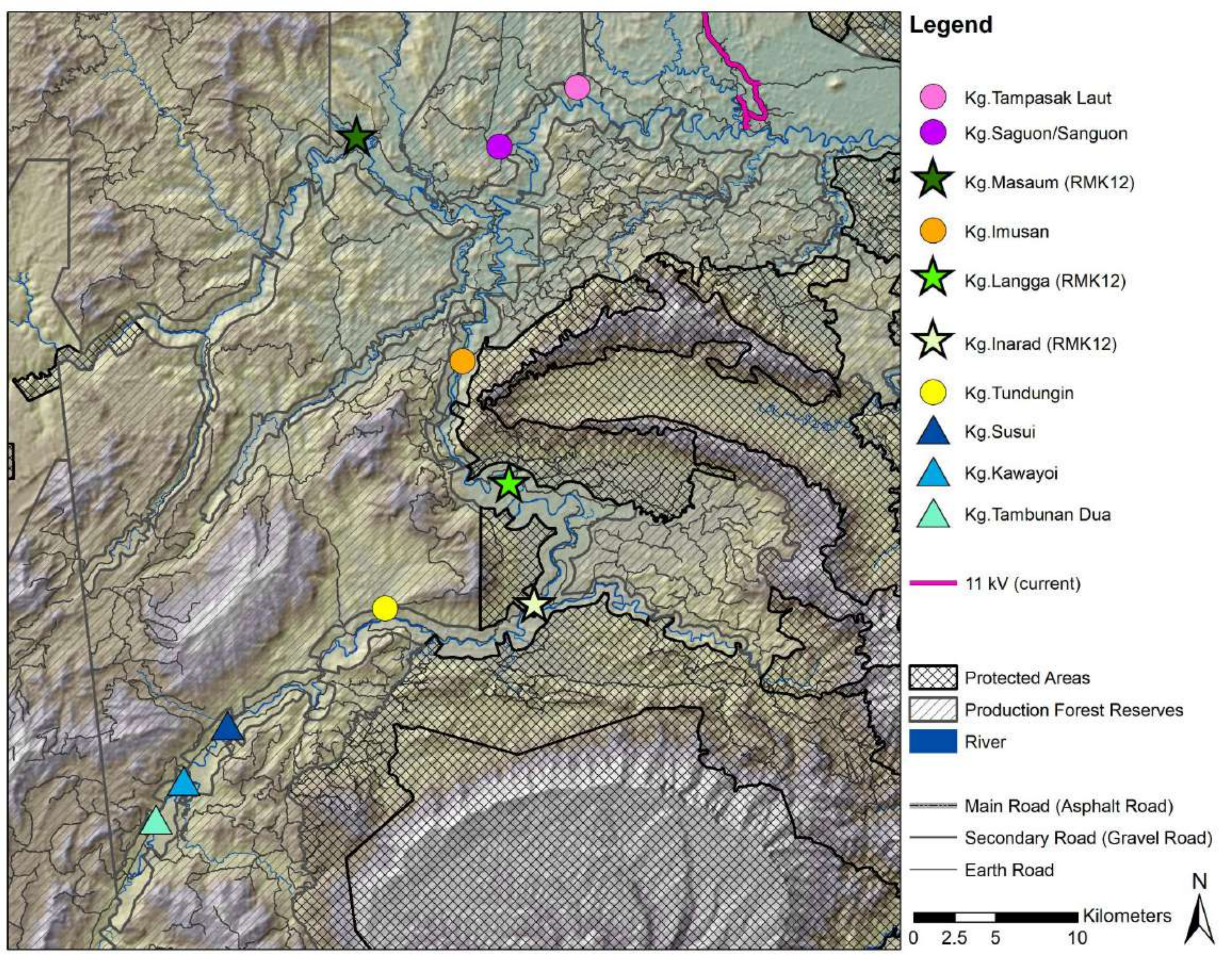
Representing Sabah's last Mile

- Beluran is one of Sabah's poorest districts.
- Diesel generators are still the predominant source of electricity in this cluster, with monthly payments reaching RM500/month for some households.
- Villages also report a minimal level of energy access generally, with the majority of cases falling under tier 2 in the Multi Tier Framework.

Opportunities for Partnership

- The clustering of communities, the demonstrated need, and the potential for renewable energy in this sub-district combine to offer a compelling case to make it a pilot district for roadmap implementation.
- Data collected through surveys and focus group discussions have uncovered opportunities to spur socio-economic development through productive end-uses for energy.
- There are also public buildings that could benefit from the stable energy resources being proposed.

Phase 1 Sample: 2022 to 2024 - Tongod

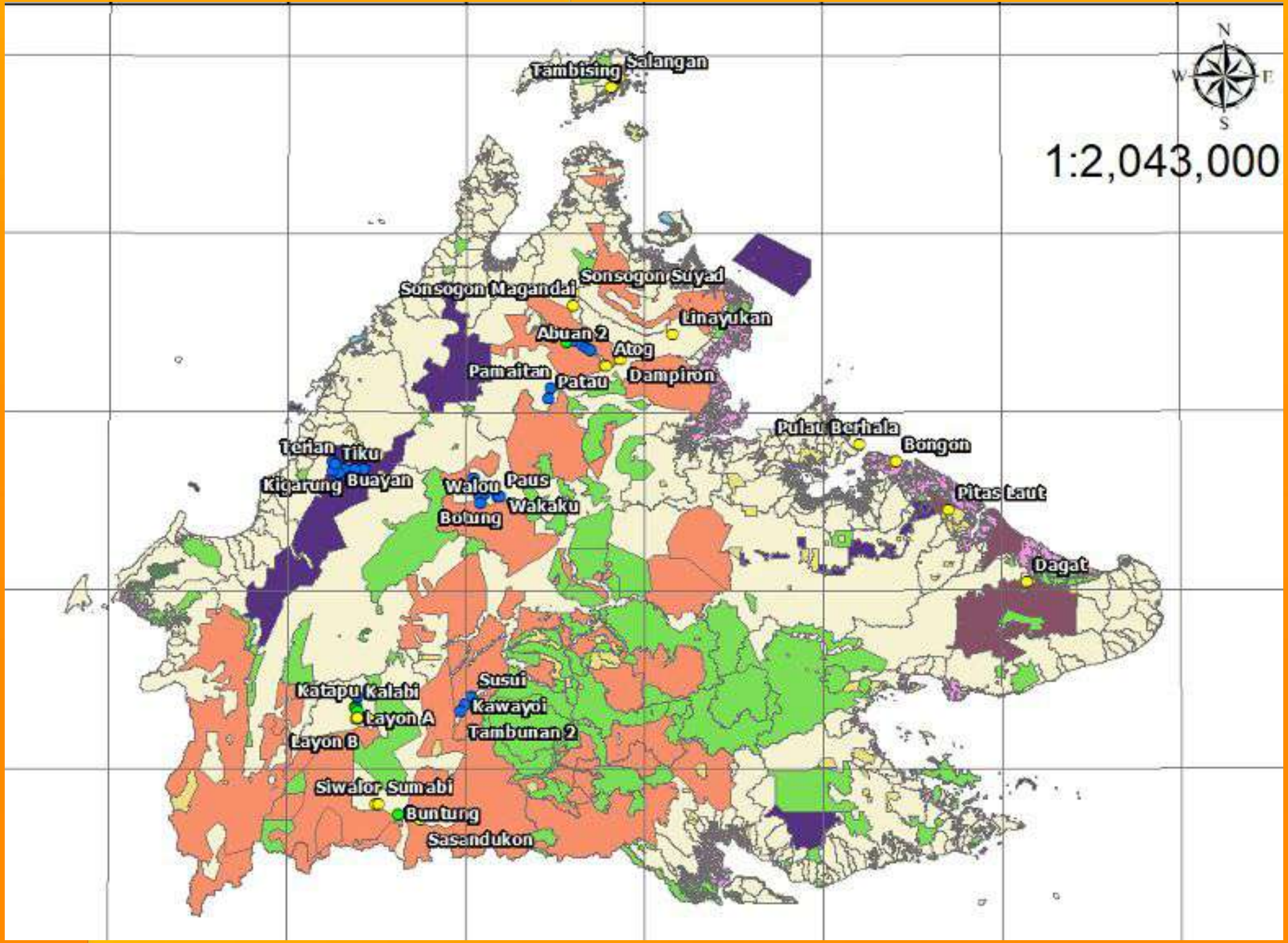


- The villages depicted represent another potential cluster for mini-grid development, containing an estimated 850 households.
- The estimated cost for electrifying the represented cluster with mini-grids is $3.5 million (further analysis required).
- 3 villages here are in RMK 12, and can be excluded from P1. However the location of the current 11 kV line should be noted.
- It is also worth noting the protected area system to the East of this village cluster.

Proposed Integrated MHP for Susui, Kawayoi, Tambunan 2:

- MHP feasibility studies were completed for Kg. Susui (35kW) & Kg. Tambunan 2 (25kW)
- Peak demand for these three villages combined has been determined to be just under 35kW
- The estimated cost for *fully* developing these MHP resources is $800,000

Phase 2: 2024-2026



Key Aims

- 28 mini-grids completed
- 5 new contracting companies trained to work on mini-grids
- “Mock” debt financing covers minimum of 30% of the costs of all mini-grids
- Village productive end-use activities supported in (at minimum) 9 of the villages
- Payment for ecosystem service (PES) models piloted in 9 villages
- Clear standards established for mini-grid development and contracting procedures

RE Output Targeted

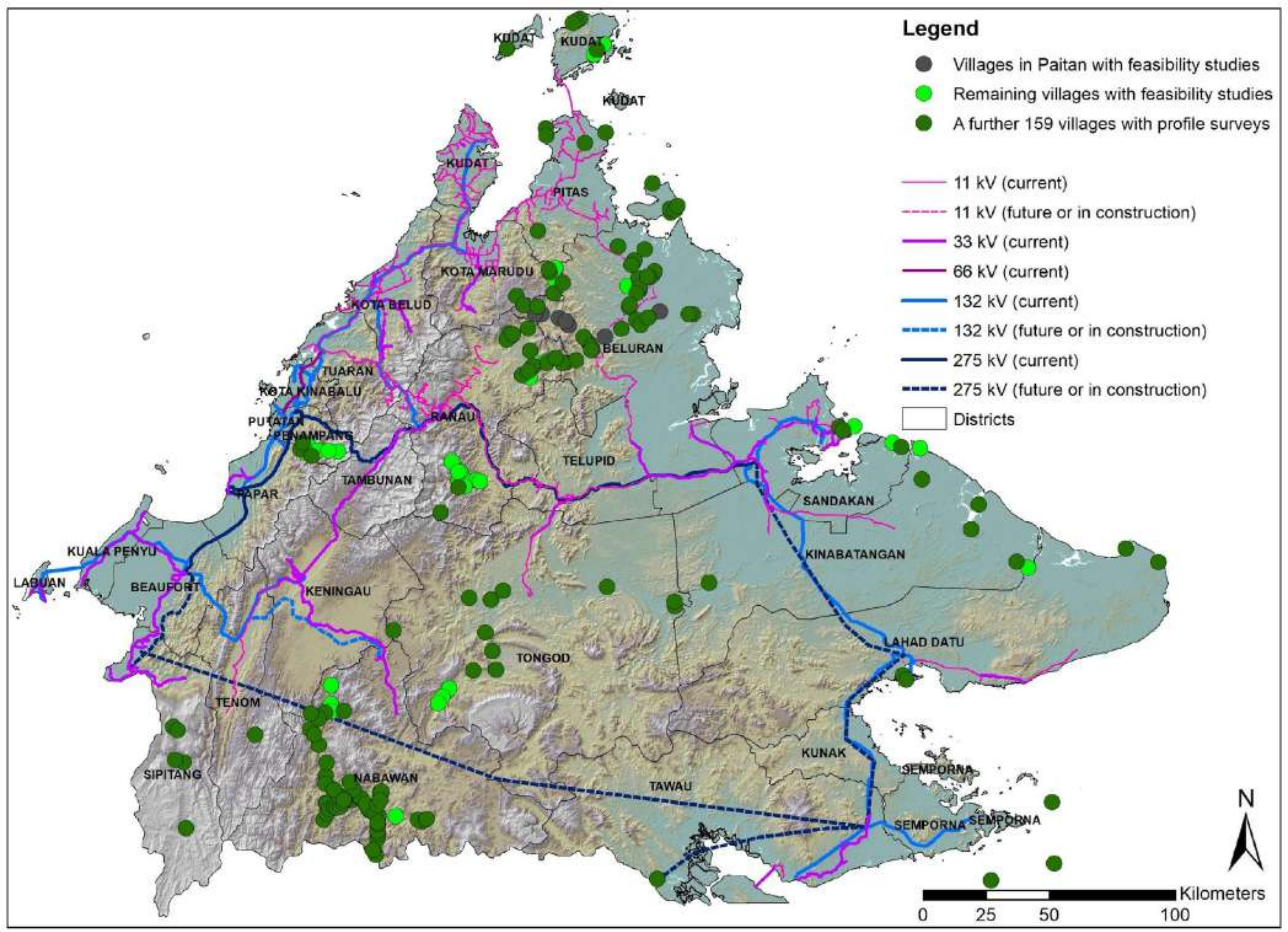
- 580 kW

Estimated Cost

- $15,000,000

Several of these studied are within the RMK12 list, again where the natural environment made compelling cases for mini-grids with RE. We would like to further study these and discuss comparisons with our government partners.

Phase 3 - 2026 to 2030



Key Aims

- 160 mini-grids completed
- Aspirational Model roll out
- Policy Framework established

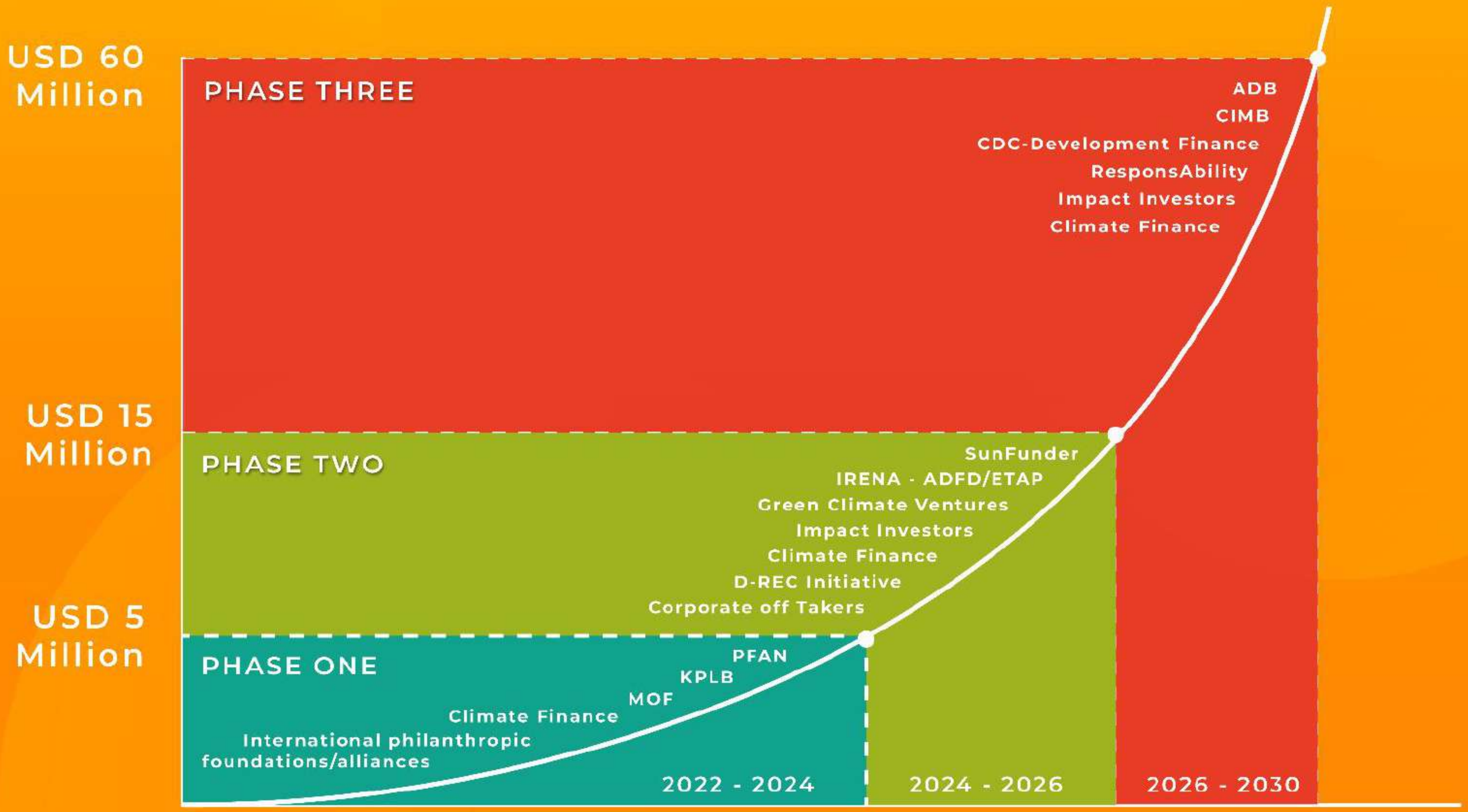
RE Output Targeted

- 3,000 kW

Estimated Cost

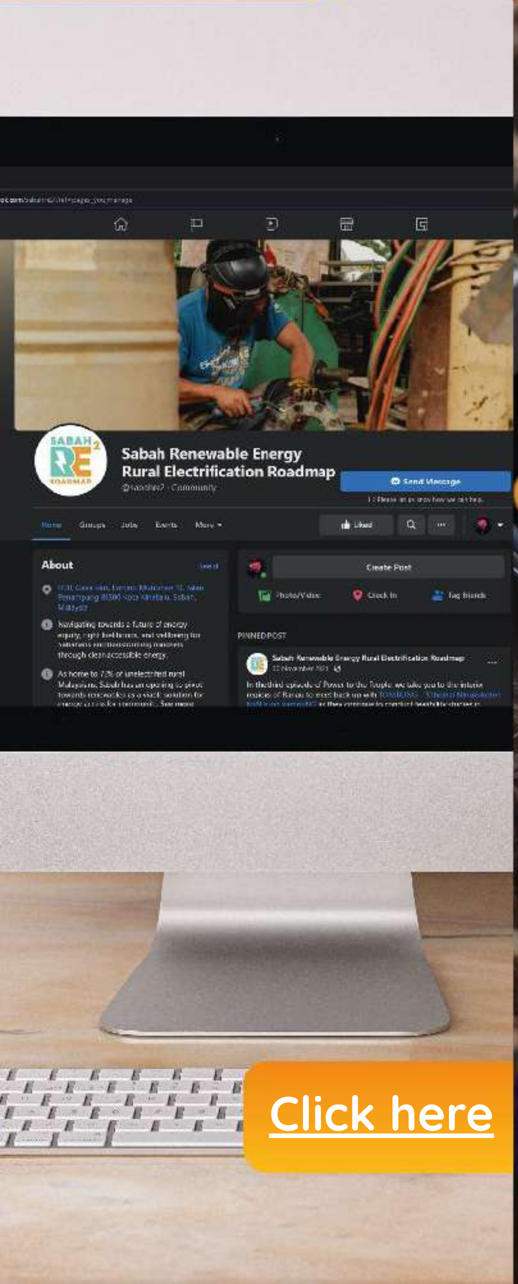
- $60,000,000

Potential Funding Partners



Communications

Facebook



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Instagram

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YouTube

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Website

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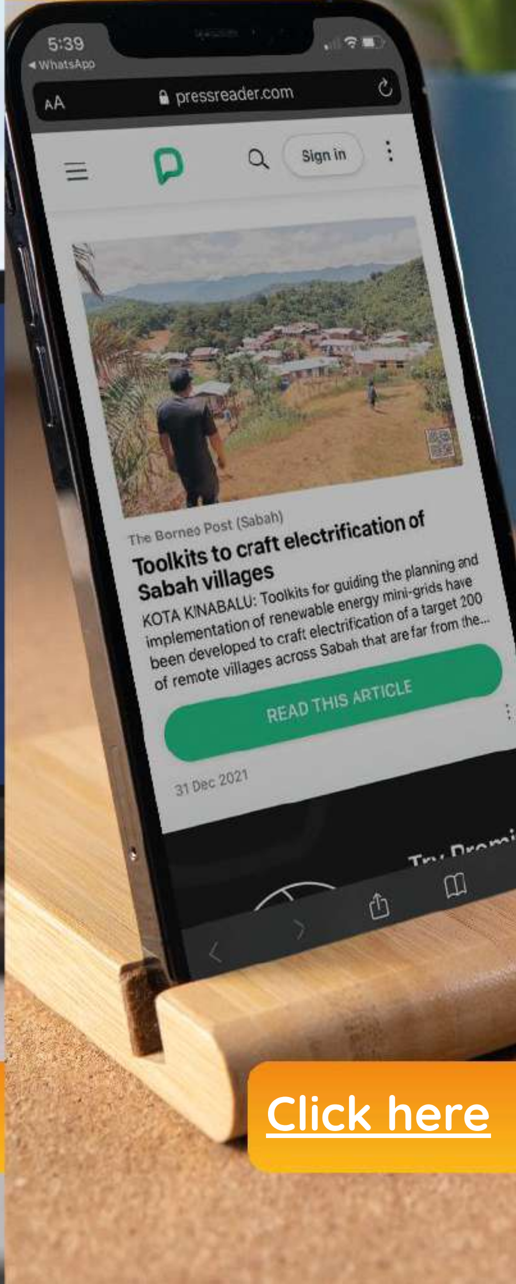

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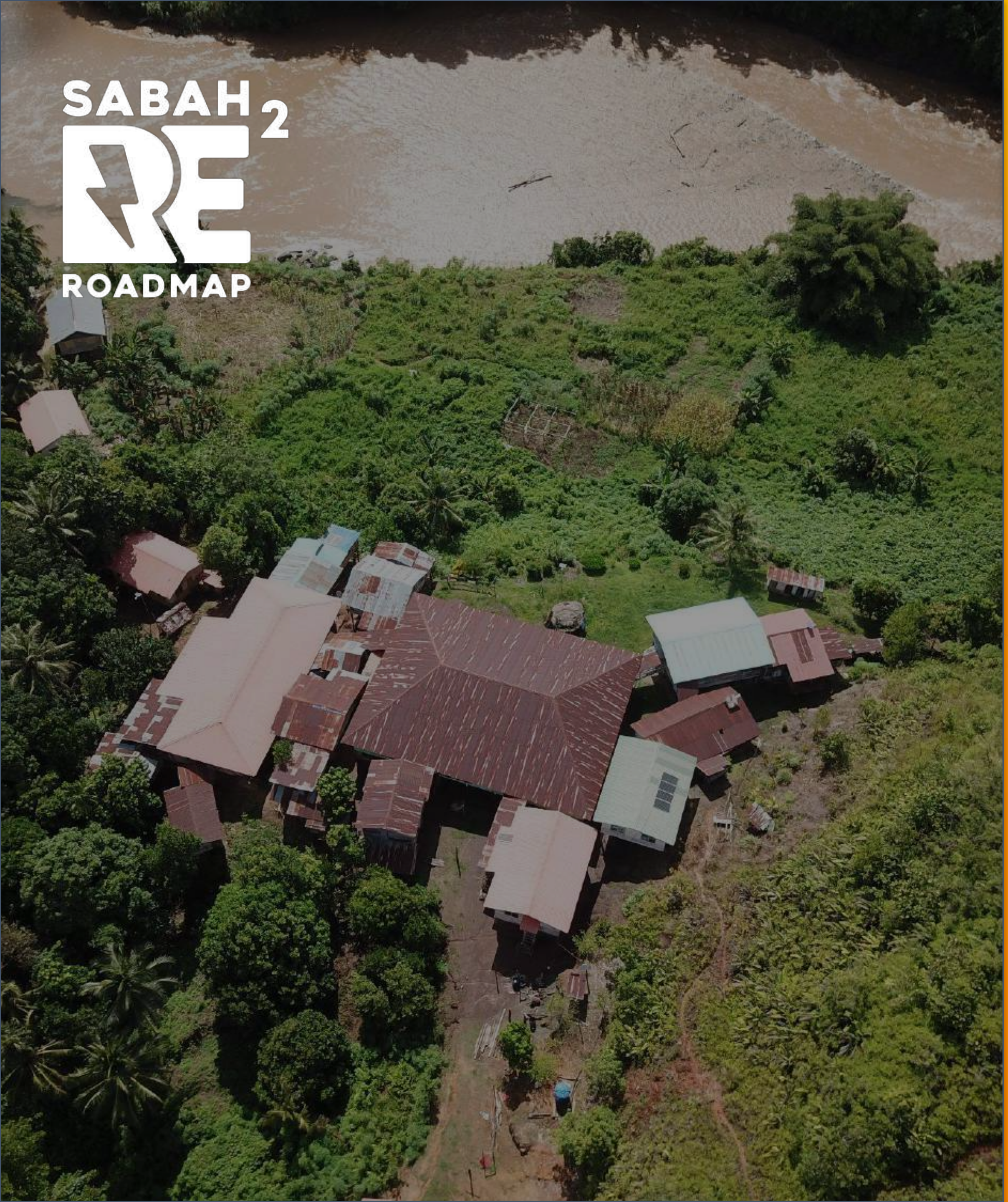
Immediate Next Steps
Jan to June 2022
Socialization amongst Government Partners for feedback, discussion and fine-tuning
Key discussion and decision with Government Partners around Launch and Aspirational Models, Selection Criteria and Phased Approach
Deeper discussions and decisions with Government Partners on Phase 1 - locations, district/s, partnerships & governance, timeline
Specialized expertise to develop Fundable Proposals for Phase 1 & engagement with funders
Project development with key stakeholders, working towards implementation of demonstration systems as agreed
Sabah Renewable Energy Conference to bring together sectors and actors in ecosystem towards building RE capacity in Sabah



For More Info

Sabah Renewable Energy Rural Electrification Roadmap

www.sabahre2roadmap.org

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