Methods and Layers Developed for Output 1: The Demand Map

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Forever Sabah
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Overview of the Process for Output 1: The Demand Map of un-electrified villages in Sabah

1. Mapping un-electrified villages in Sabah
2. Mapping the transmission and distribution grid in Sabah
3. Mapping remoteness of un-electrified villages in Sabah
4. Potential mini-grid systems for un-electrified villages
5. Potential mini-grid systems for 206 community profile villages
6. Mini-grid systems assessed for the 40 feasibility study villages

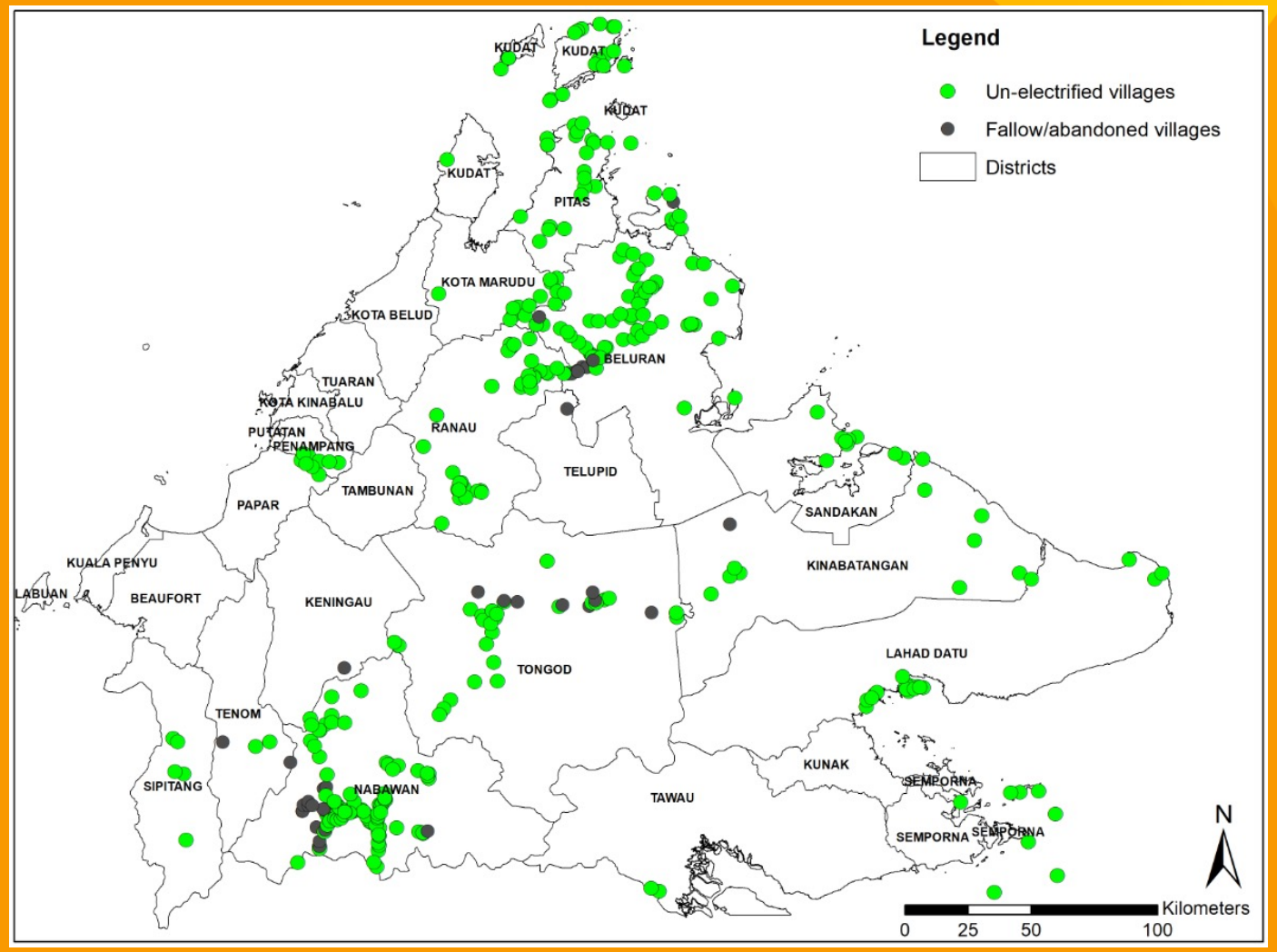
1. Mapping un-electrified villages in Sabah

- Over the past nine months efforts have been made to identify the estimated 400 un-electrified villages and to characterize their relationship to infrastructure, economic activities and topographical contexts.
- The following process was used to identify un-electrified villages: (defined as lacking access to continuous reliable electrical power)
    - First, the field teams reached out to their community networks to gather initial information on possible un-electrified villages and a list of un-electrified villages was drafted.
    - Second, District Officers and Assistant District Officers were contacted, for the districts with un-electrified villages to: (1) help with the checking and verification of the current un-electrified village list; and (2) provide additional information on other un-electrified villages that were then added to our list.
    - Third, we went through various Forest Management Plans, Environmental Impact Assessments and other reports and questionnaire survey data to identify further un-electrified villages.
    - Fourth, we also found a number of un-electrified villages from an array of publically available information sources online.
- Several iterations of the above methods were undertaken, with each iteration of the un-electrified villages list being checked for duplicates, with potential duplicates verified and removed, and the names of villages standardized to the best of our ability.
- For each village, coordinates were obtained from a variety of methods. These included: extracting locations from existing sources (such as reports and previous surveys); collecting locations from the field using GPS, and gathering coordinates from Google Earth, mapcarta.com and other online sources. Coordinates were checked and verified to the best of our ability.
- Through the checking and verification process, some villages that had been included were found to have electricity 24/7 from the grid and in this case they were removed from the un-electrified villages list.

1. Mapping un-electrified villages in Sabah

- Additionally, some villages were identified as ‘fallow’ or partially abandoned. People may keep homes in ‘fallow’ villages but they were only lived in for part of the year or by part of the family. Reasons behind residents moving out, permanently or temporarily, include lack of access to electricity and schooling. The future electrification of villages may therefore see people moving back to their native lands.
- As of the end of December 2021, we had a total of 391 villages within our un-electrified village list that have been verified through the methods outlined above.
- Of the 391 villages, 46 are categorized as being fallow (with community members still having lands and homes within the area and inhabiting the village to a greater or lesser degree) or currently abandoned (though some communities would return to the village if there was access to electricity and schooling).
- **Figure 1**, shows the location of the 391 un-electrified villages.

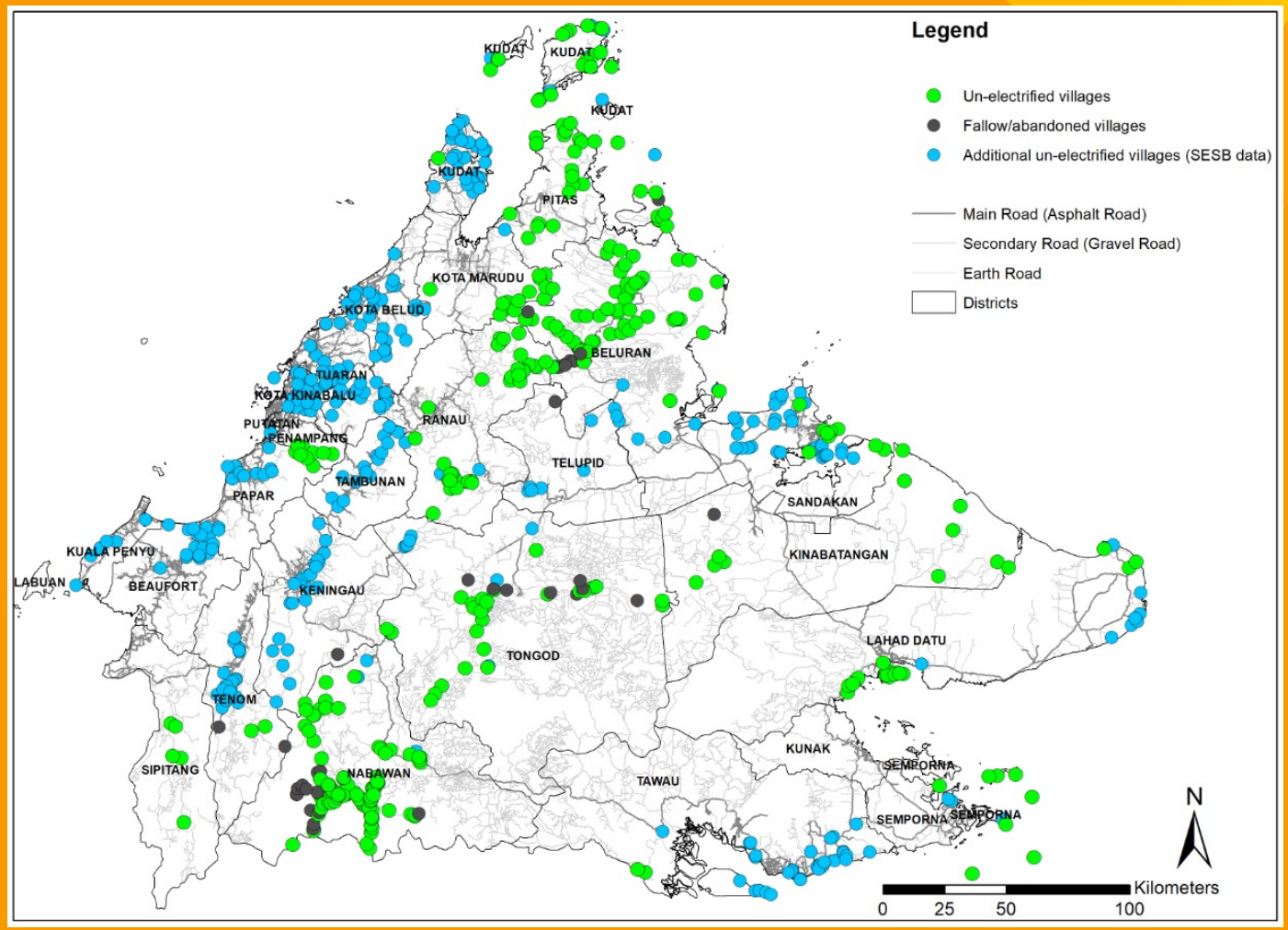
Figure 1: Map showing the location of the 391 un-electrified villages, 46 of which are categorized as fallow or abandoned.



1. Mapping un-electrified villages in Sabah

- SESB provided the team with a list of over 500 un-electrified villages assembled over a number of years.
- After removing those already in the list of 391, as well as a number of errors, including locations that were clearly not villages, there were 355 villages in the SESB list that were additional to our list, which can be seen in **Figure 2**.
- Many of the 355 villages were in zones associated with roads and other infrastructure and where government has substantially increased grid access in recent years. It is likely that most of the villages on the SESB list have thus been electrified since the list was made.
- We will therefore need to undertake a verification process for the SESB villages before we add them (or do not add them) into our existing un-electrified village list of 391.
- The following slides thus pertain to the 391 un-electrified villages as well as villages selected for the 200 Project Porfolio profiling surveys and 40 Feasibility Studies.

Figure 2: Map showing the 391 un-electrified villages and additional villages (from SESB data) that may also be un-electrified



2. Mapping the transmission and distribution grid in Sabah

- Over the past several months we have developed a spatial layer/map for Sabah's transmission and distribution grid, to include 275kV, 132kV, 66kV, 33kV and 11kV lines.
- Initial methods included the digitization of 275kV and 132kV transmission lines and power stations from Map 12.1 in the Sabah Structure Plan 2033 (SSP2033), see **Figure 3;** and use of the publicly-available "Sabah Grid Network" schematic map, from the Sabah Electricity Supply Industry Outlook 2019 (Energy Commission, 2019), see **Figure 4**.
- We then used high resolution Spot (1.5m) imagery from 2015; and importantly, Google Earth and Street View, to look on the ground to improve the location accuracy of the grid lines and to identify additional grid lines.
- Google Earth and street view were key to the distribution grid layer as they have the most recent satellite images that enabled us to: (1) track the development of new transmission/distribution lines under construction; (2) identify various transmission/distribution lines in the same path; and (3) identify and correct locations of intake/distribution/ switching stations that also helped us map the grid network.
- In fact, Street View greatly assisted us in the identification of the capacity of the grid lines, by allowing us to identify the number of insulator discs per phase (**Figure 5**).
- Data from SESB was used to help identify a future distribution grid line connects between Beluran and Pitas.

2. Mapping the transmission and distribution grid in Sabah

Figure 3: Map 12.1 from the SSP2033 that shows current/proposed transmission lines and power stations

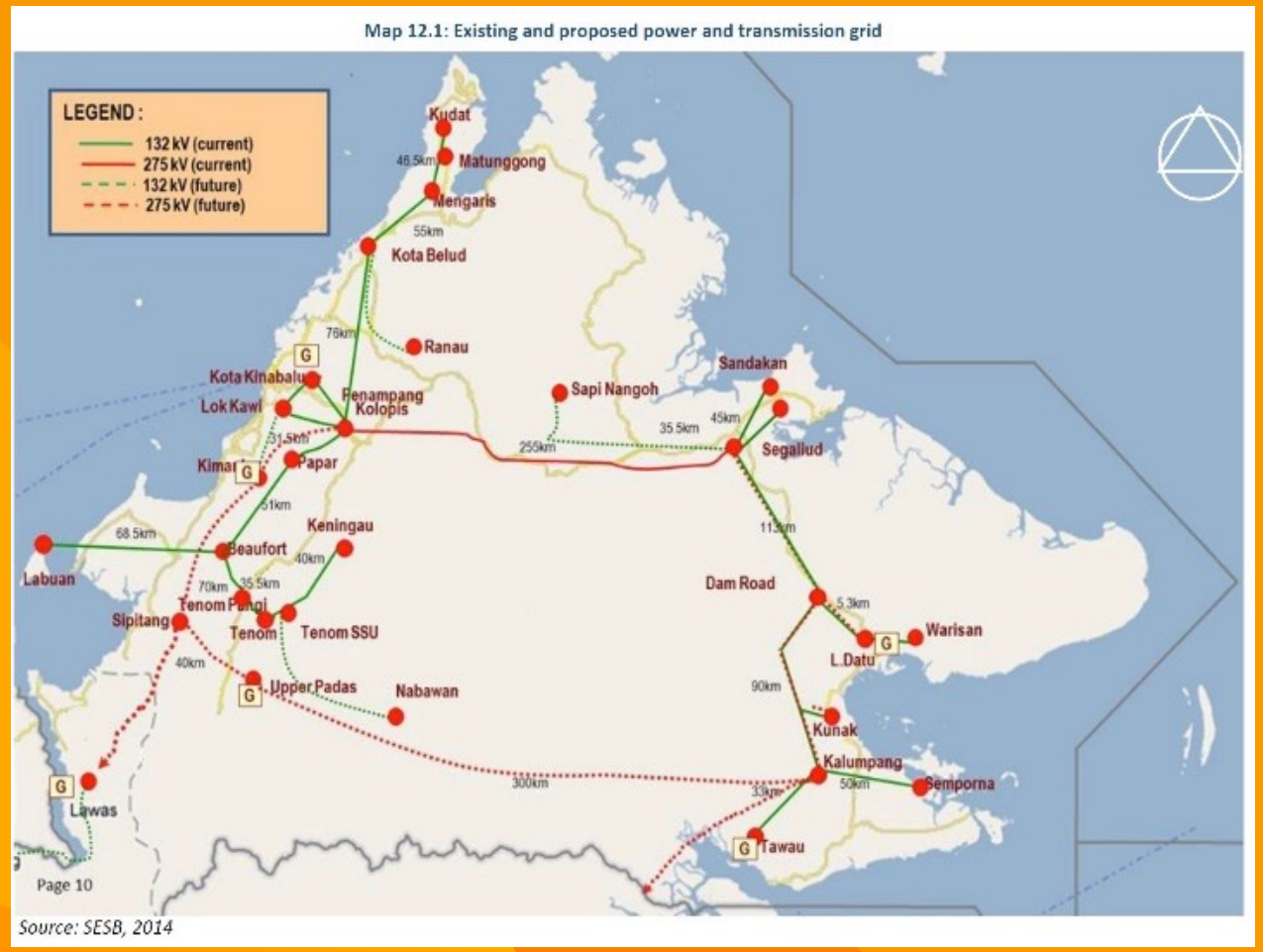
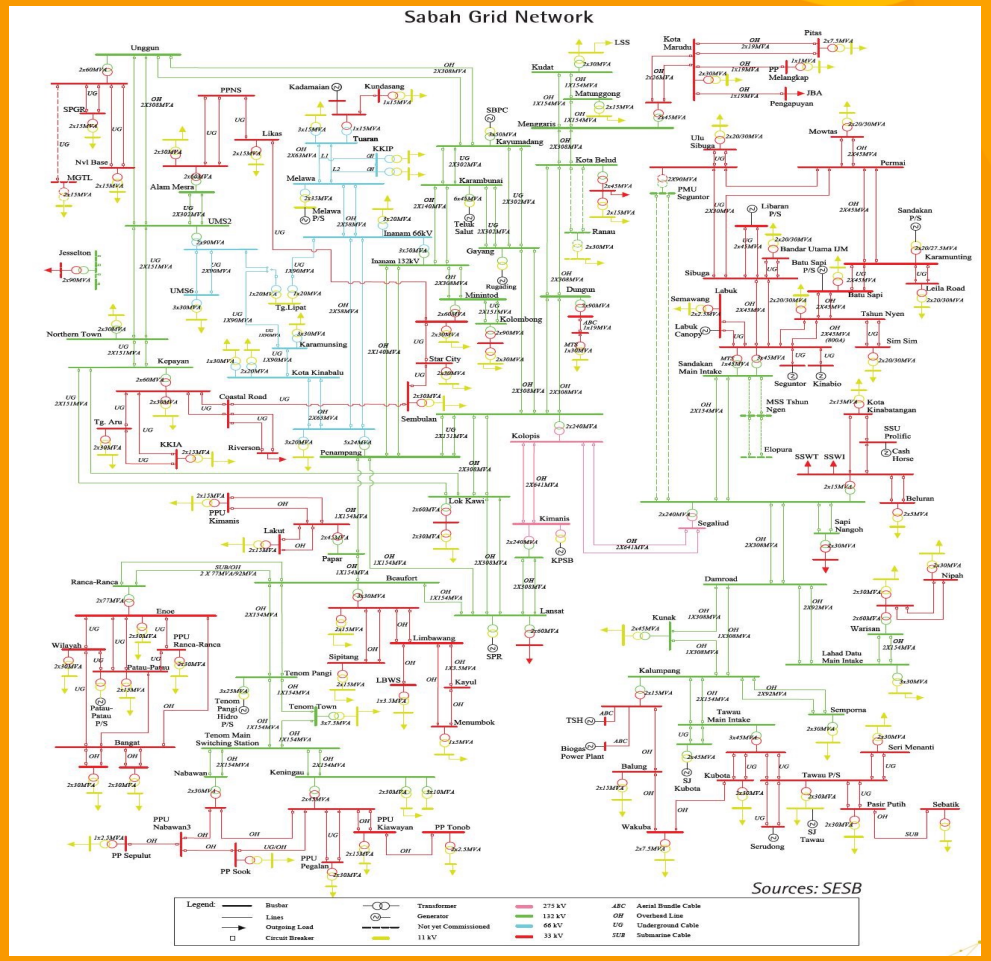


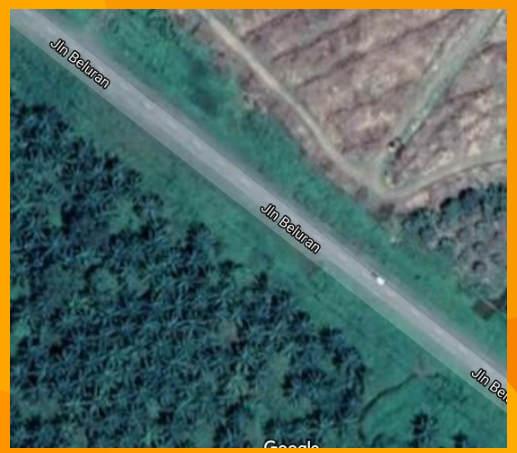
Figure 4: Grid network schematic from the Sabah Electricity Supply Industry Outlook 2019

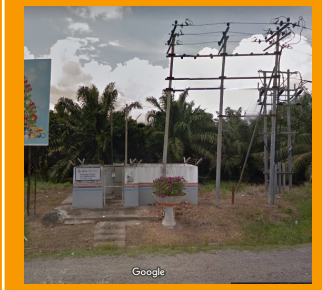


2. Mapping the transmission and distribution grid in Sabah

Figure 5: Images from Google Earth and Street View showing visible transmission and distribution lines, switching stations, and insular discs per phase, enabling us to identify distribution line capacity

1. Presence of transmission line	2. Identification of connecting points	3. Tracing transmission grid lines	4. Number of insulator discs per phase





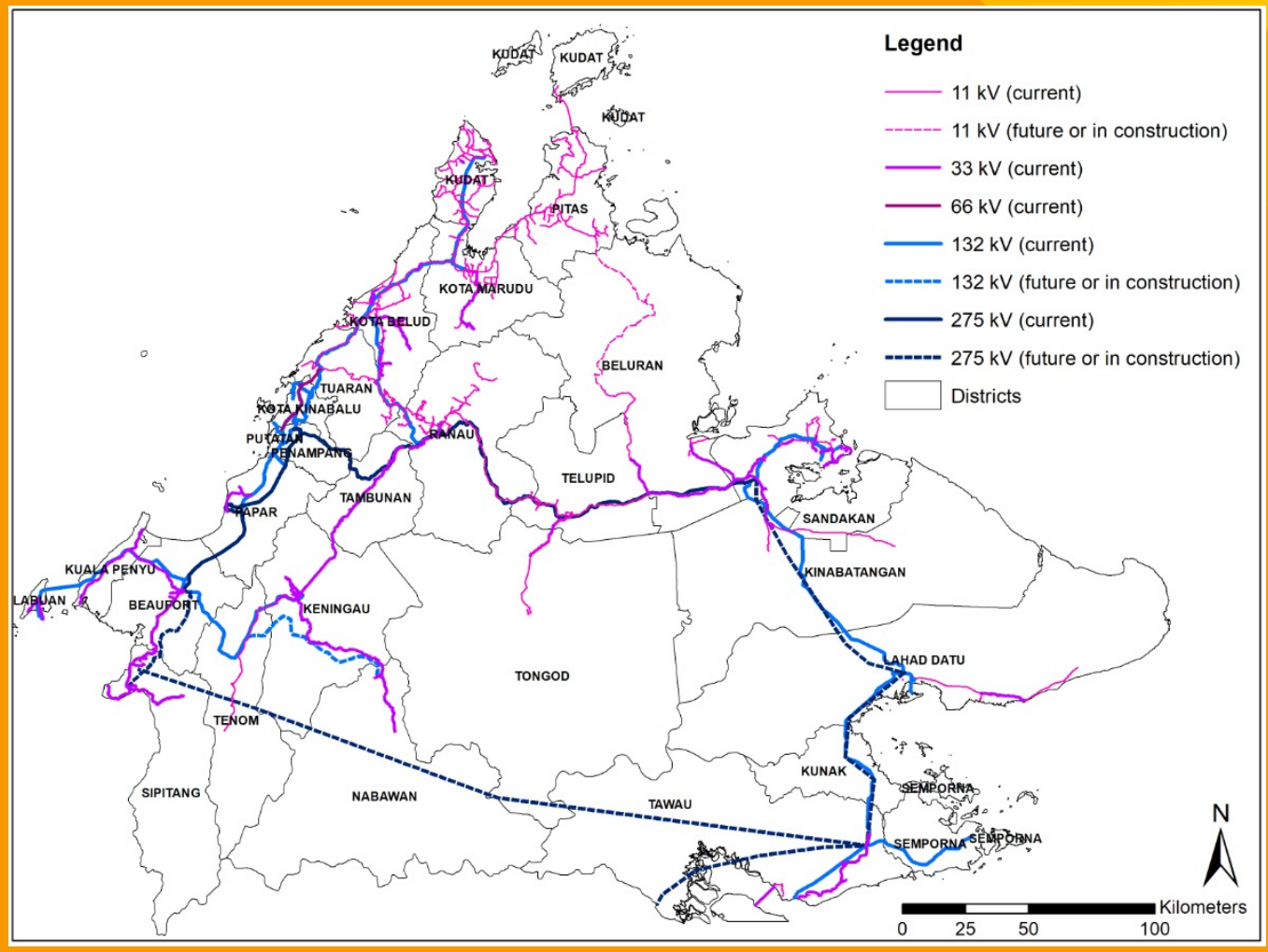
2. Mapping the transmission and distribution grid in Sabah

- The current digitised distribution grid layer is estimated to be around 90% complete for major lines, but no attempt yet to trace out final distribution lines to individual villages and installations (see **Figure 6**).
- So far, 4,928 km of grid in Sabah has been mapped, including existing lines, planned extension lines and those under construction, see **Table 1**.
- Feedback from SESB will shape future work on the grid.

Table 1: Summary of the line capacity and lengths mapped

Grid line type	Length mapped (in km)
11kV (existing)	1,733
11kV (in construction or planned)	99
33kV (existing)	945
66kV (existing)	34
132kV (existing)	1,058
132kV (in construction or planned)	79
275kV (existing)	350
275kV (in construction or planned)	630
Total length	**4,928**

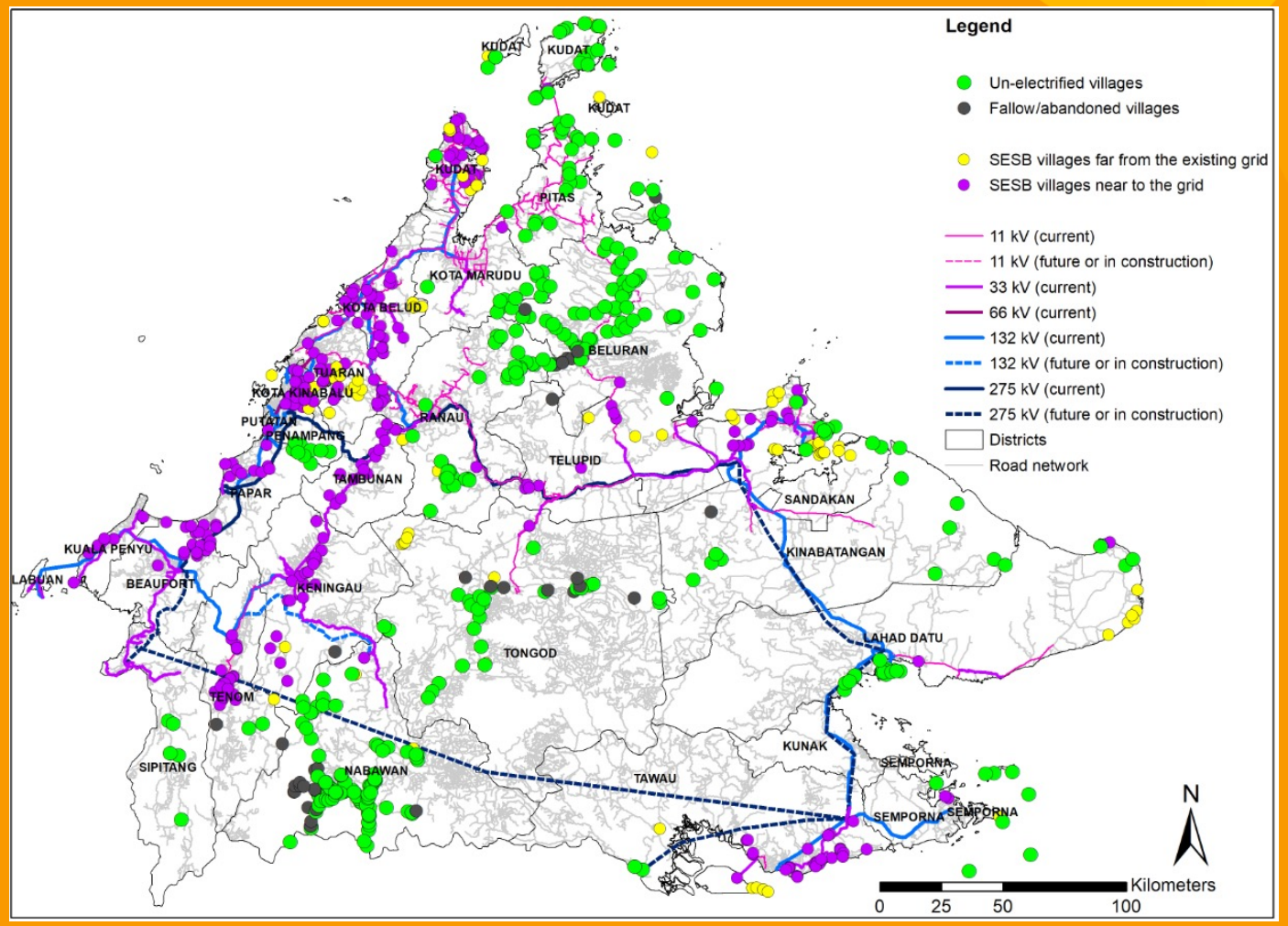
Figure 6: Map showing the identified transmission and distribution lines in Sabah.



2. Mapping the transmission and distribution grid in Sabah

- As noted above SESB provided the team with a list of un-electrified villages that included 355 villages that were additional to our list of 391.
- 256 of these "SESB Villages" were within 2 km of current grid lines and 96 were further away from the grid and not in our current list (see **Figure 7**).
- It is likely that most of the 256 villages close to the grid have already been electrified by the government, while a large proportion of the 96 that are far from the grid may lack continuous reliable power, even if some have received off-grid generator/solar hybrids.
- We therefore need to undertake a verification process for the SESB villages before we add them (or do not add them) into our existing un-electrified village list.
- Therefore, the following slides pertain to the 391 un-electrified villages as well as villages selected for the 200 Project Portfolio profiling surveys and 40 Feasibility Studies.

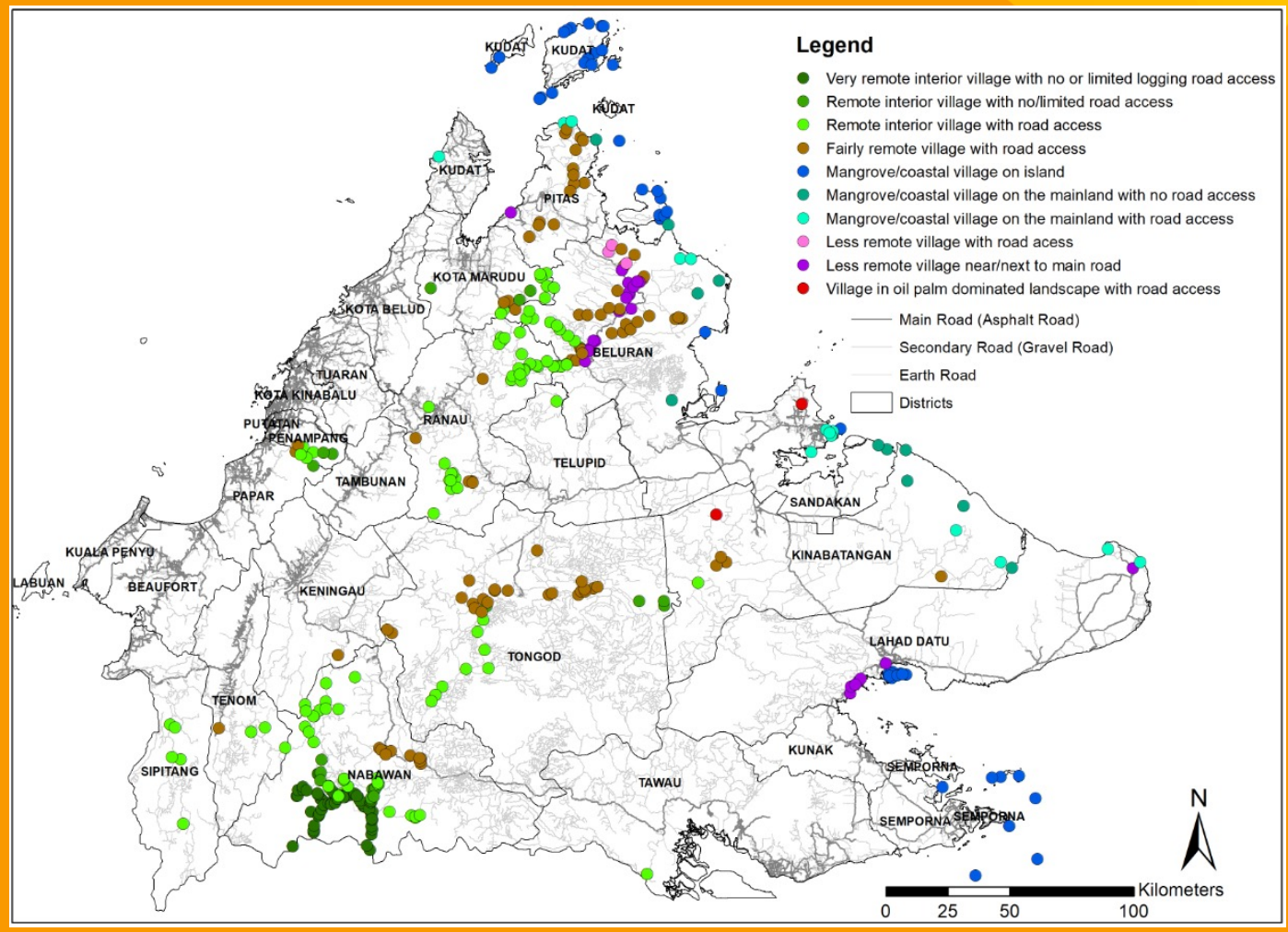
Figure 7: Map showing the transmission and distribution lines overlaid with the 391 un-electrified villages within our current list and additional 355 un-electrified villages from SESB data



3. Mapping remoteness of un-electrified villages in Sabah

- To understand the degree of remoteness for un-electrified villages we categorised villages into ten distinct categories based on their environmental and infrastructural contexts. These included villages:
  - That were very remote with limited access by road
  - That were remote and with limited road access
  - That were remote but with road access
  - That were fairly remote with road access
  - That were within mangroves and were coastal communities on islands or places only accessible by boat
  - That were within mangroves on the mainland but had access to roads
  - That were less remote villages with secondary/gravel road access, then less remote villages with main road access
  - That were within oil palm landscapes with road access
- The resulting map can be seen in **Figure 8**.

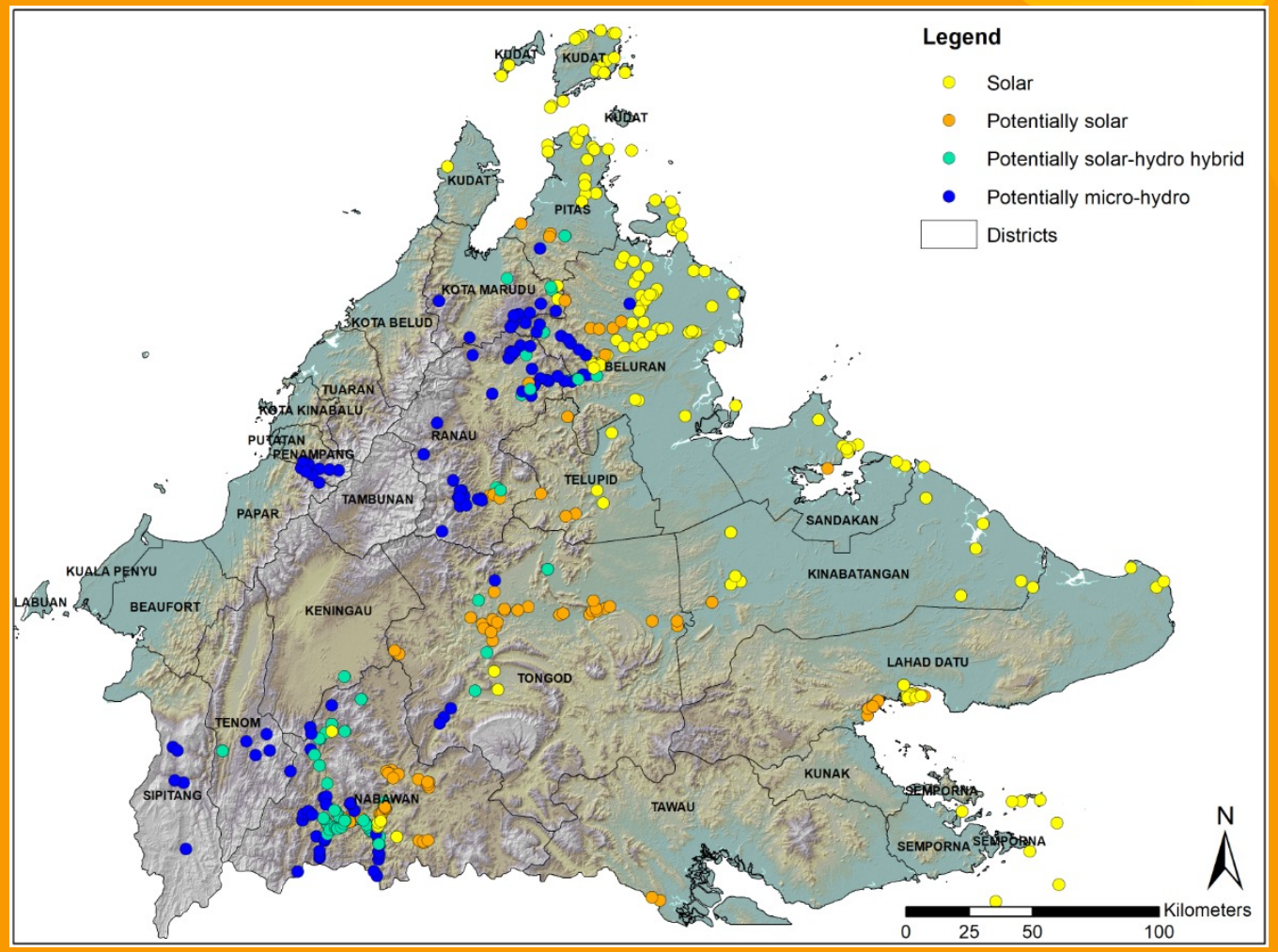
Figure 8: Map showing the location of the 391 un-electrified villages, and their category of remoteness



4. Potential mini-grid systems for un-electrified villages

- Using elevation and topographical hill shade data, along with stream flow data (generated by GIS modelling), we attempted to predict what type of renewable generation might be suitable for un-electrified village mini-grids.
- For those in the flat lowlands, solar PV systems may be the only viable option.
- Within areas that are fairly flat with undulating hills, solar PV systems may also be the best option.
- In areas that might have micro-hydro potential, but where we are uncertain of adequacy, we have classified those villages as potentially having solar-hydro hybrid potential.
- Lastly, we identified those villages that were in rugged areas, near to streams that likely have micro-hydro potential.
- This desk-top approach is an initial attempt to quantify which system may be appropriate for each village. However, this is difficult to assess for some villages and will need ground level assessments in the future.
- Our predictions of the mini-grid systems types can be seen in **Figure 8**.

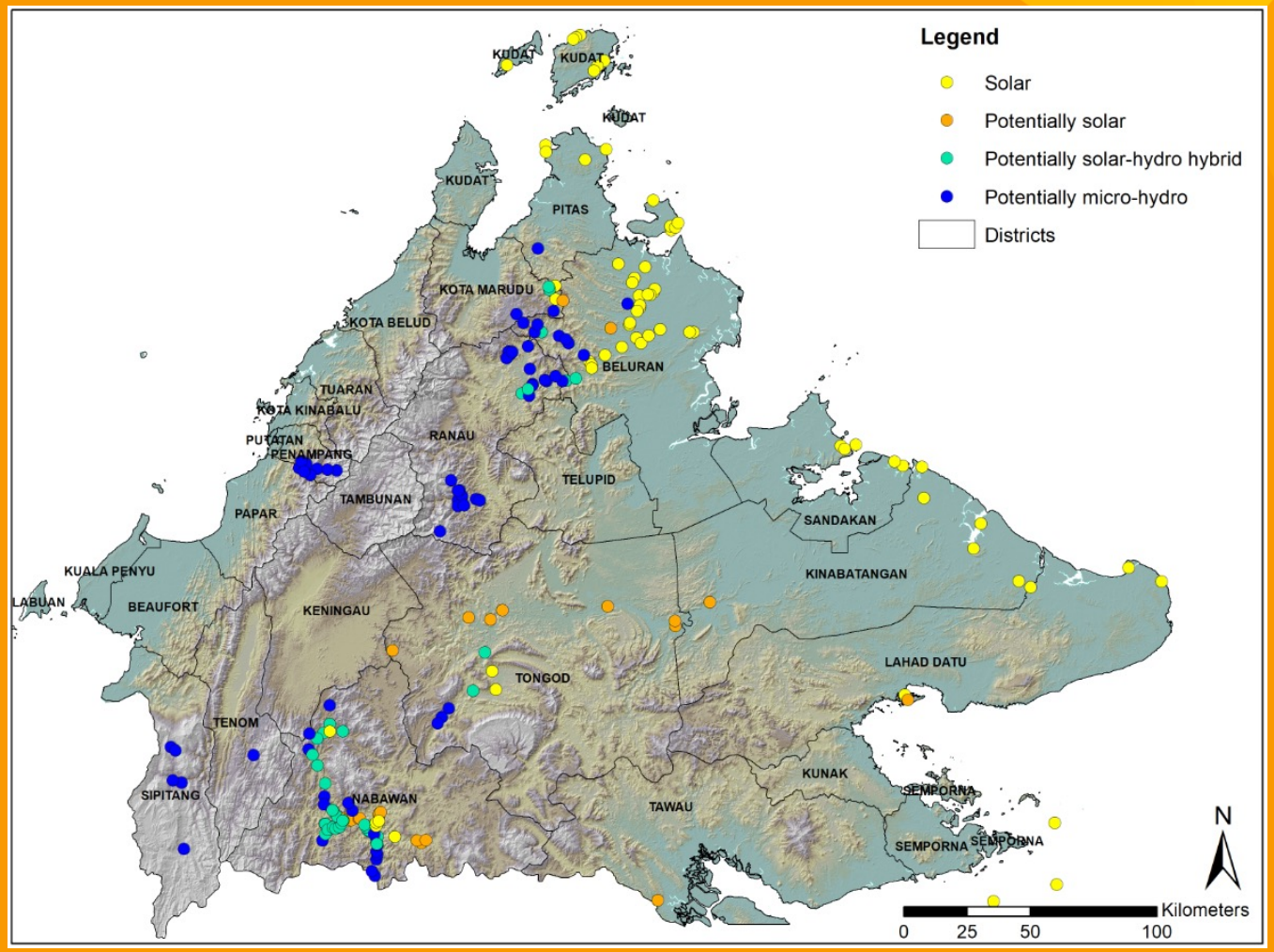
Figure 8: Map showing the location of the 391 un-electrified villages, and their category of remoteness.



5. Potential mini-grid system for the 206 community profile villages

- For the Project Portfolio a total of 206 un-electrified villages (all included within our current 391 verified un-electrified village list) were surveyed.
- A sub-set of 40 of these villages were assessed through a Feasibility Study of the type of mini-grid system required (see subsequent slide).
- However, based, on the desk-top approach we used to categorize the potential mini-grid system that would be viable for each village, we estimate that:
  - 69 villages would require solar PV systems,
  - A further 23 would likely need solar PV systems,
  - 44 villages may be suitable for a solar-hydro hybrid system,
  - And 68 villages may be located within areas suitable for a micro-hydro system.
- These 206 villages, along with their potential mini-grid system can be seen in **Figure 9**.

Figure 9: Map showing the location of the 206 un-electrified villages within the community profile portfolio and potential system types



6. Mini-grid systems assessed for the 40 feasibility study villages

- For Output 4, 40 feasibility studies were conducted to assess the types of electricity generation and mini-grid systems that would be required for each community.
- These 40 studies actually represent providing power to 44 un-electrified villages.
- The location, mini-grid system type, and village population category can be seen in **Figure 10**.

Figure 10: Map showing the location of villages that had feasibility studies for mini-grid system types along with the village population