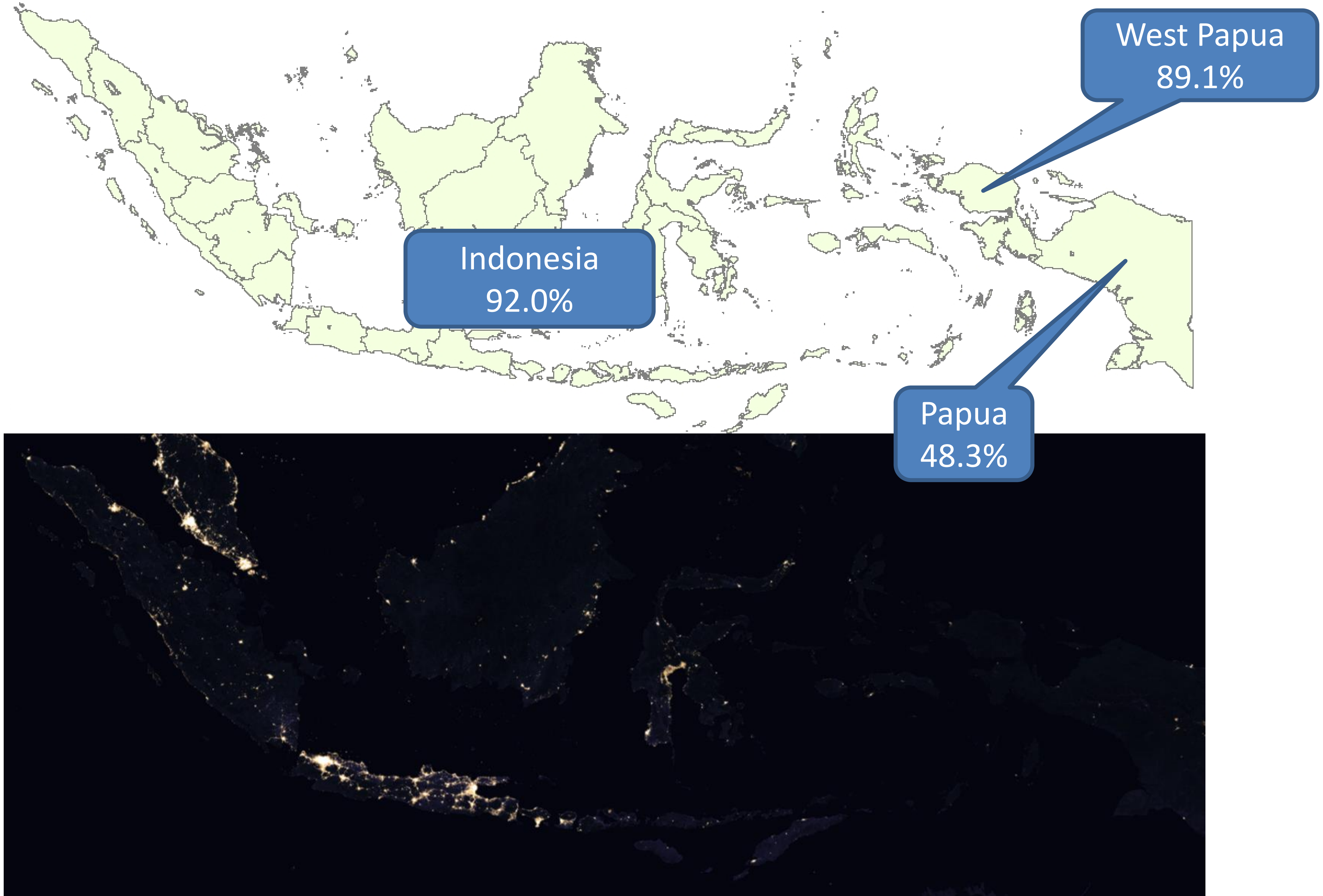
Planning for Universal Access in Eastern Indonesia

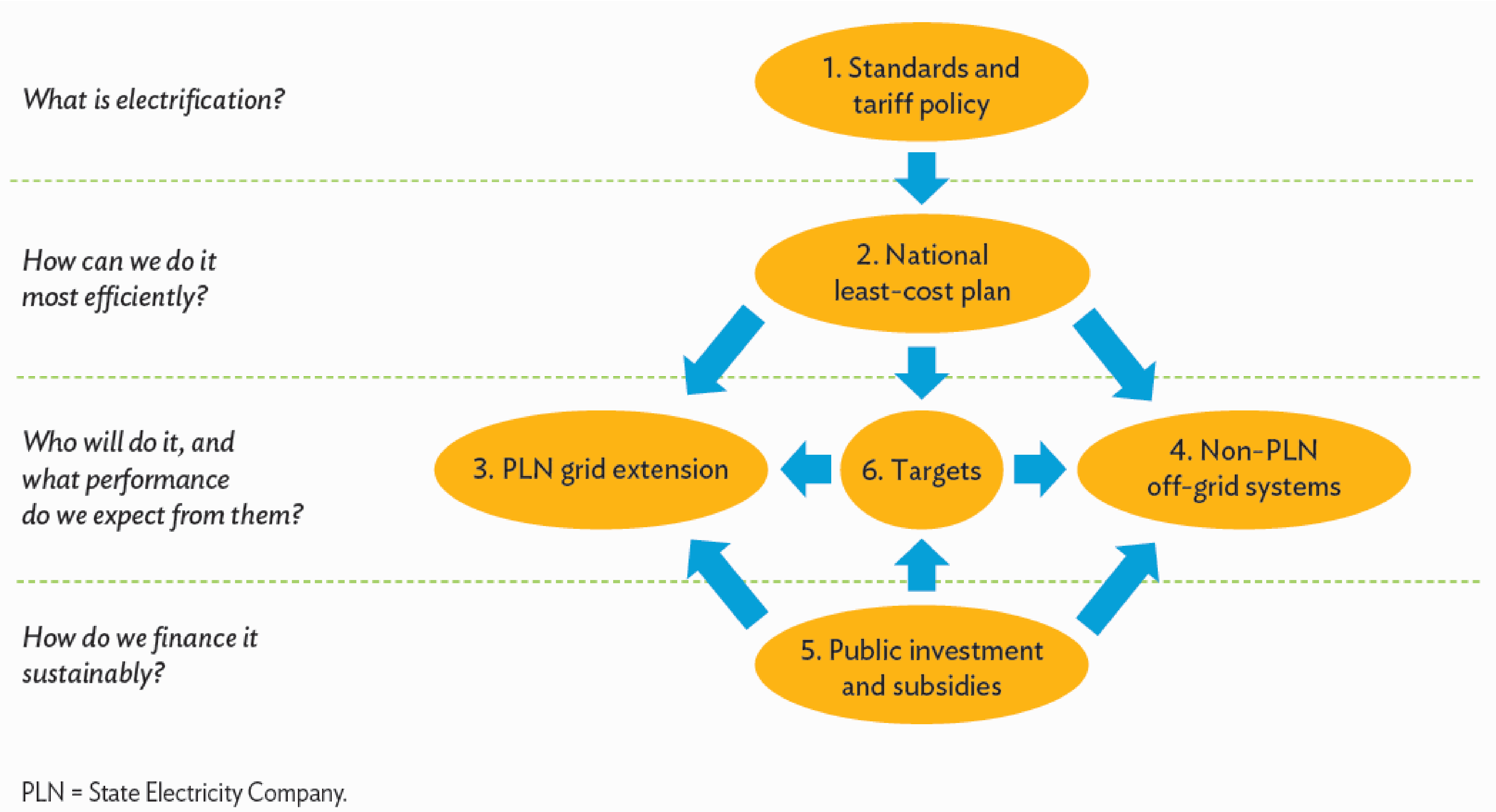
Asia Clean Energy Forum

6 June 2017

Current electrification ratio



Elements of an electrification paradigm



What do we need from an electrification plan?

1. Accuracy
2. Timeliness
3. Coverage
4. Granularity
5. Optimality (least-cost)
6. Funding requirements

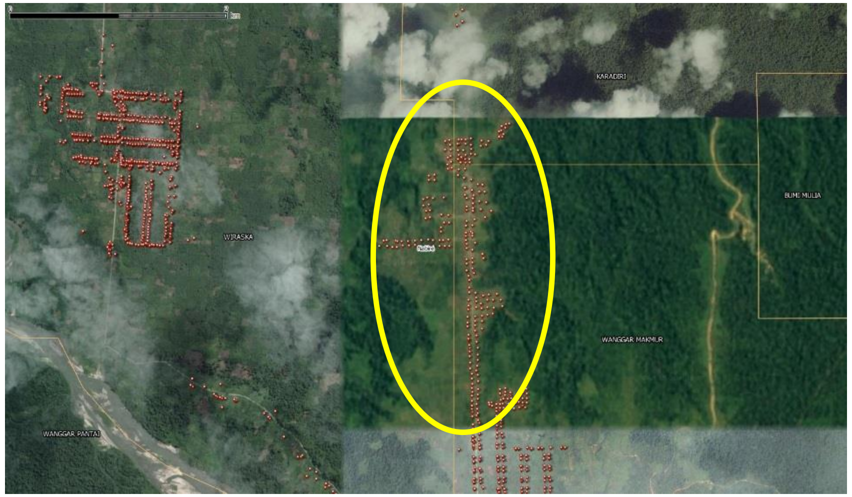
What infrastructure…
…should be built where…
….and how much it will cost

The planning methodology

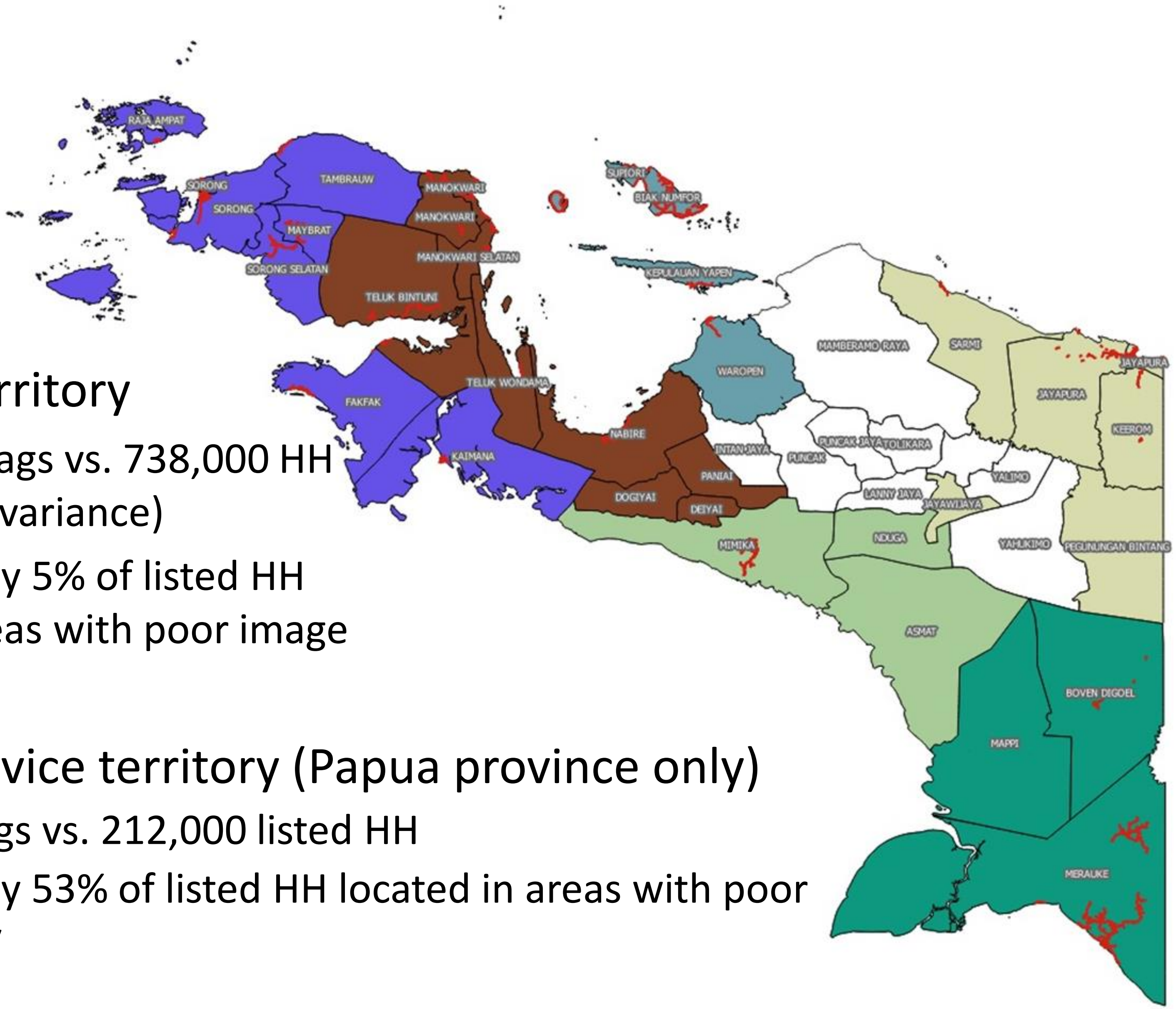
- Carried out with PLN for provinces of Papua and West Papua
  - Approx. 459,000 km2 (bigger than California, smaller than Spain)
  - Approx. 4.3 million inhabitants
- Supported by ADB and AFD
- 8 months to carry out

1. Rooftop Tagging

- Manual identification of households
- Machine learning also possible
- Issues
  - Low resolution
  - Cloud cover
  - Old imagery
- Three imagery sources
  - Google Earth
  - Bing Maps
  - HERE Maps
- Low resolution data can be augmented by "cartometric inference"



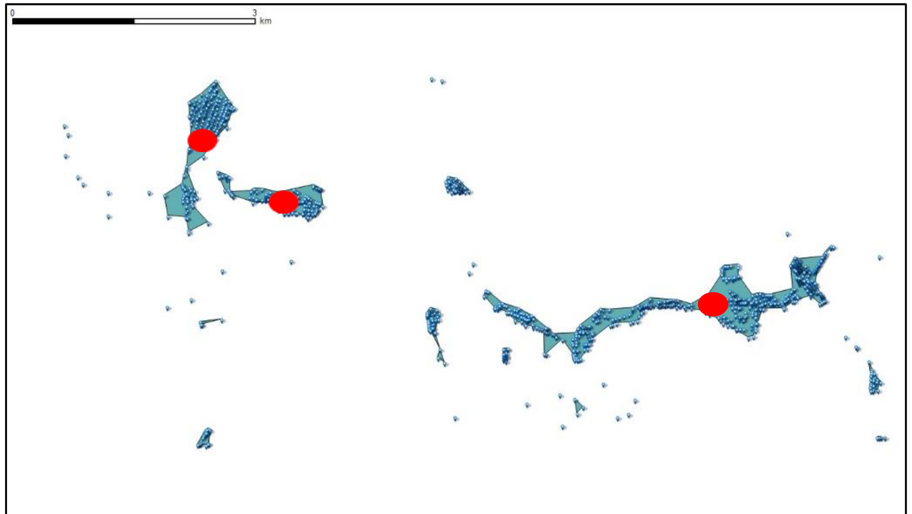
Rooftop tagging results



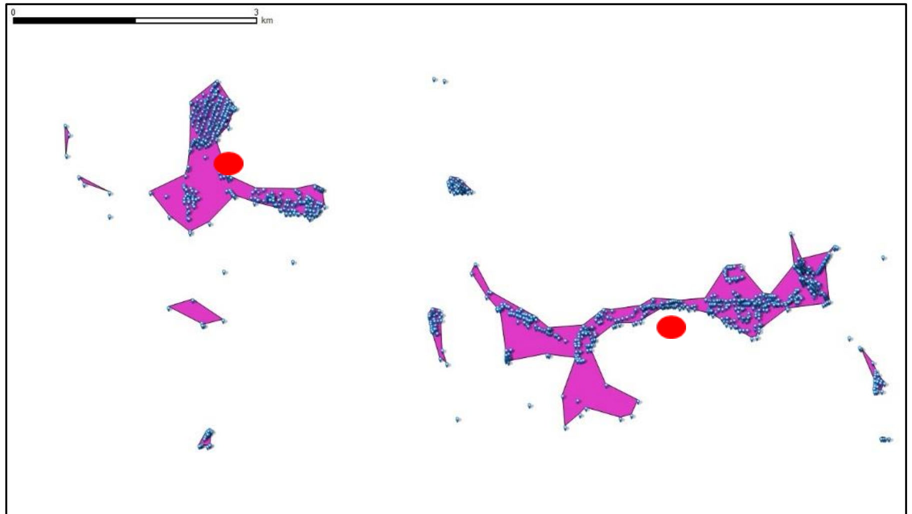
- PLN service territory
  - 675,000 HH tags vs. 738,000 HH listed (< 10% variance)
  - Approximately 5% of listed HH located in areas with poor image quality
- Kabupaten service territory (Papua province only)
  - 80,000 HH tags vs. 212,000 listed HH
  - Approximately 53% of listed HH located in areas with poor image quality

2. Settlement delineation

- A “settlement” is a group of households that can be connected by LV reticulation
- If one household is within a specified distance of another (the “proximity critierion”) they are in the same settlement
- A “node” is the centroid of a settlement and is characterized by the number of households in the settlement



300 m proximity

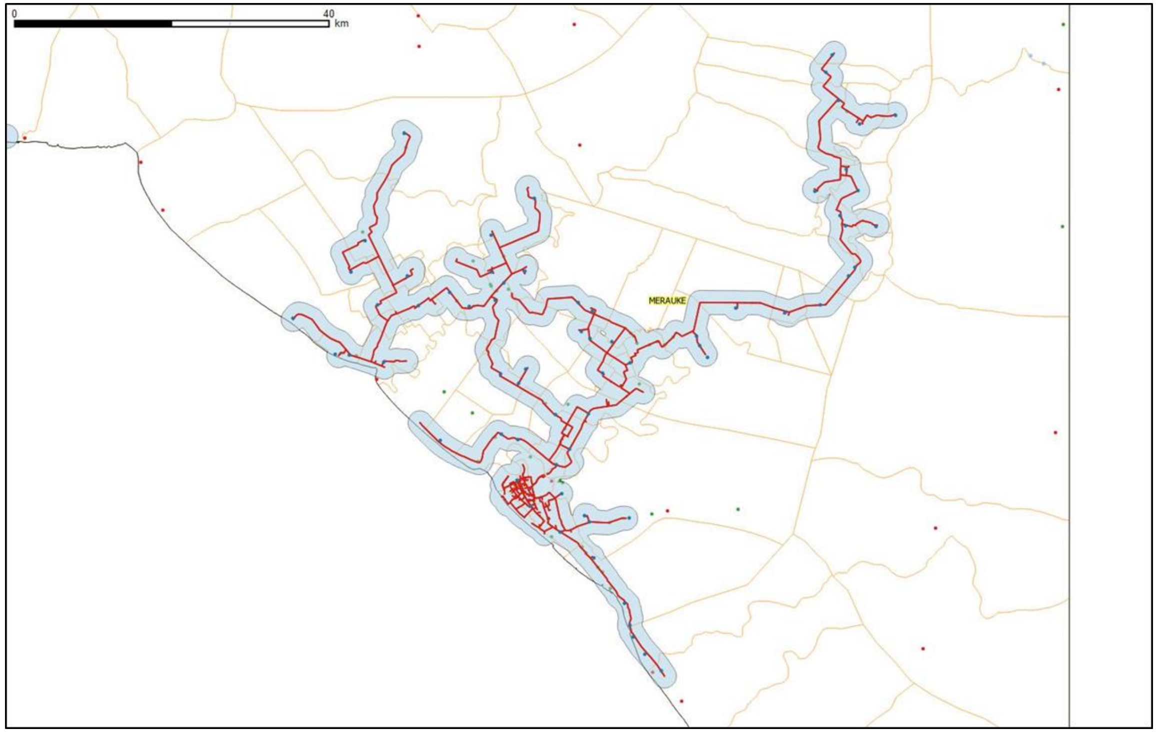


500 m proximity

small blue dots = rooftop tags colored polygons = aggregated settlements red dots = selected polygon centroids (nodes)

3. Identification of existing assets

- Utility provides location of MV lines and isolated diesel units
- Can be done with GPS in field or by digitizing maps prepared in office with field engineers
- Buffer placed around existing MV lines to distinguish between rural electrification and in-fill connections

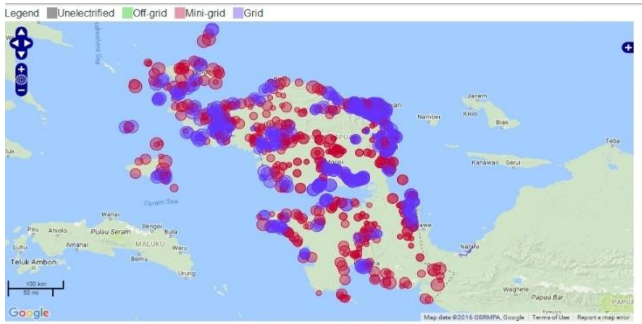


4. Unit costing & demand forecasting

- Compile unit costs and performance of candidate technologies
  - Grid extension
  - PV mini-grids (other mini-grid technologies could be defined)
  - Solar home systems
- Define settlement demand model
  - Settlement population
  - Economic growth
  - Population growth
  - Based on power sales on existing mini-grids: sales vs. number of consumers
  - Other social and commercial infrastructure can be explicitly modeled

5. Optimization

- Apply Network Planner
  - Developed by The Earth Institute at Columbia University (http://networkplanner.modilabs.org/)
  - Enter nodes, technology costs and performance, demand model, financial parameters
  - Applies Kruskal's algorithm to determine minimum spanning tree and determines least-cost technology for each node
- An economic, not engineering, model



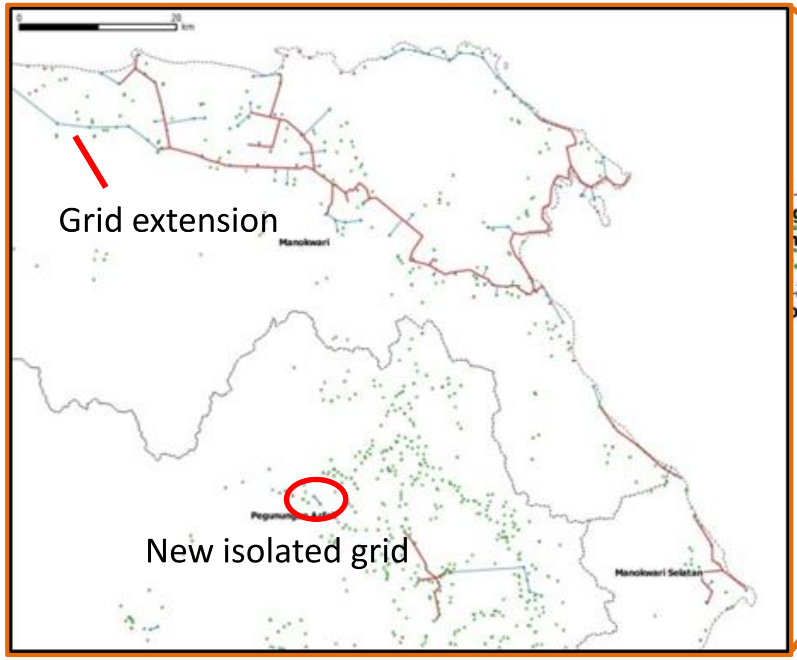
Sorong and Manokwari area 15Sept2016

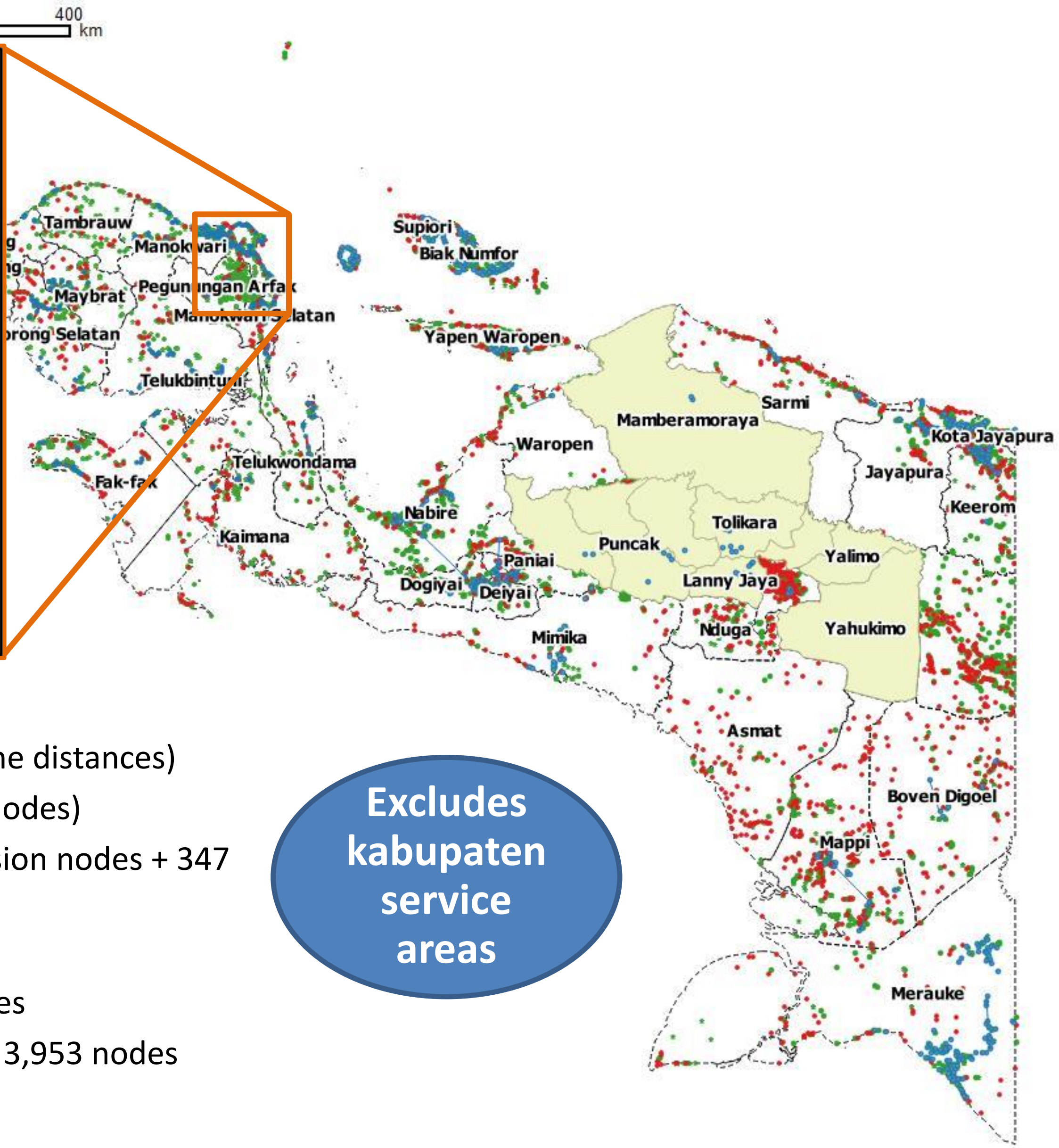
	Scenario 5106	Scenario 5105
Unelectrified Nodes	N/A	N/A
Off-grid nodes	0	0
Off-grid initial cost	$0	$0
Off-grid recurring cost	$0	$0
Off-grid cost	$0	$0
Off-grid cost levelized	$0.00 / kWh	$0.00 / kWh
Off-grid diesel fuel cost	$0.00	$0.00
Mini-grid nodes	116	287
Mini-grid initial cost	$9,774,018	$33,871,854
Mini-grid recurring cost	$7,641,656	$27,224,162
Mini-grid cost	$17,415,674	$61,096,015
Mini-grid cost levelized	$2.46 / kWh	$2.40 / kWh
Mini-grid energy storage cost	$5,716,589	$20,593,147.29
Grid nodes	192	189
Grid initial cost	$71,754,149	$117,602,871
Grid recurring cost	$171,285,771	$397,873,148
Grid cost	$243,039,920	$515,476,019
Grid cost levelized	$0.34 / kWh	$0.30 / kWh
Grid length existing	312,035 m	536,620 m
Grid length proposed	435,116 m	537,934 m
	Download	Download

Scenario 5105 - Sorong area 15Sept16
Scenario 5104 - Manokwari and Sorong area
Scenario 5103 - Sorong area 10Sept16
Scenario 5099 - Manokwari area 8Sept16v1 rerata 1
Scenario 5098 - Sorong area 8Sept16 rerata 1
Scenario 5097 - Sorong area 8Sept16
Scenario 5096 - Manokwari area 8Sept16v1
Scenario 5093 - Manokwari area 6Sept16v1
Scenario 5092 - Sorong area 5Sept16v1 clone clone clone pembangkitan 0.30
Scenario 5091 - Sorong area 5Sept16v1 clone clone clone clone

Imbenti	25	$149,776	$90,391	$35,145	mini-grid
Imboisrati	19	$122,767	$80,928	$29,624	mini-grid
Inggof	142	$881,467	$525,530	$180,213	mini-grid
Inggof	16	$108,035	$66,099	$26,319	mini-grid
Inoduas	263	$1,944,630	$1,115,495	$345,451	grid
Inya	27	$159,597	$103,361	$37,354	grid
Inyora	16	$108,035	$66,099	$26,319	mini-grid
Iriati	5,152	$207,648,143	$98,152,736	$16,461,542	grid
Iseren	52	$316,739	$195,827	$69,598	mini-grid
Jowen	139	$854,458	$507,592	$171,713	grid
Kaironi	60	$360,935	$220,647	$78,561	grid
Kaironi	182	$1,173,653	$692,771	$229,693	grid
Kali Merah	224	$1,546,864	$898,761	$289,655	grid
Kalitami Ii	102	$623,656	$375,720	$129,714	mini-grid
Kampung Baru	60	$360,935	$220,647	$78,561	grid
Kampung Baru	43	$245,534	$152,270	$55,090	grid

Results – technology by settlement





- Existing 20 kV grid 2,589 kms
- Future 20 kV grid 1,583 kms (straight line distances)
- Existing Grid in buffer connected (473 nodes)
- Future Grid 888 nodes (541 grid extension nodes + 347 isolated MV grid nodes)
- Future mini-grid 1,147 nodes
- Future off grid (SHS/SEHEN) 2,004 nodes
- Future Individual building (SHS/SEHEN) 3,953 nodes

Results – program costs

Assumes 90-96% electrification ratio depending on region	Number of HH	Number of settlements (nodes)	Initial capital cost (USD)	Present value of recurring costs (USD)
SHS systems	17,098	5,957	$5,430,361	$12,425,053
PV mini-grids	53,799	1,147	$110,689,664	$104,564,585
Grid extension (connected to existing grid)	128,189	541	$185,569,034	$183,772,778
Grid extension (new – not connected to existing grid)	47,095	347 (81 systems)	$69,081,704	$65,410,590
Within existing grid buffer	428,440	473	n/a	n/a

Conclusions

- First-order rural electrification plans can be prepared relatively quickly, cheaply and accurately for large areas
- Results must be combined with local knowledge and field studies – “confirmatory studies”
- Additional studies are needed to ensure adequate generation and transmission

THANK YOU !

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