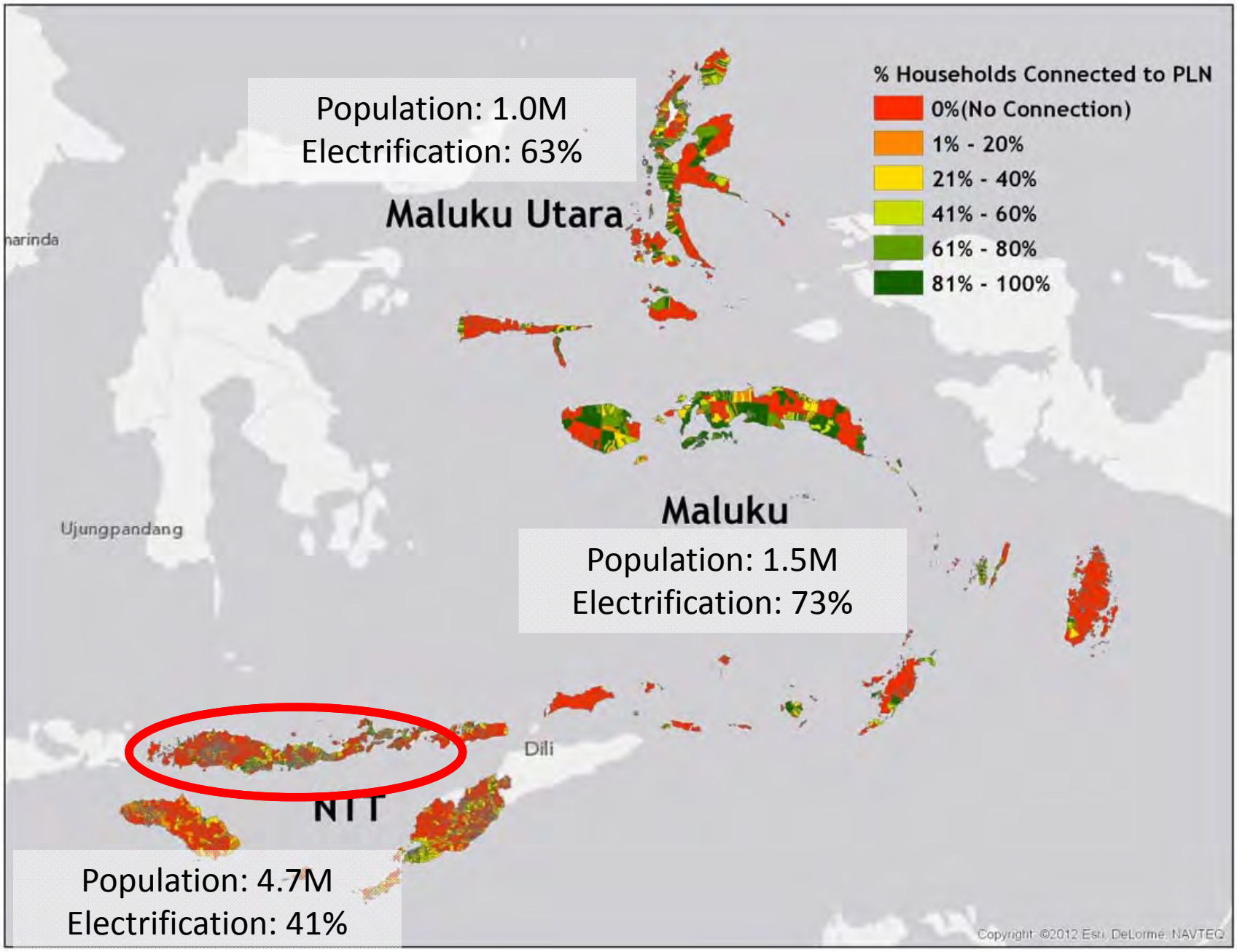
# Target area: Islands, varying terrain & small settlements




Sources: BPS Statistics Indonesia. *2010 Population Census* & 2011 PODES.

# Goal: Overview

Creating a planning platform for PLN: nimble, flexible, open and “financing-grade”.

- Many of 70M w/out elec. are harder to reach
- Geography/scale forces O(MW) scale diesel
- Demand/location/nature of demand local
- SME/Industry/Agric/Social demand. Varies.
- What is the existing coverage?
- Costs to expand grid/minigrid/off-grid
- Is there a local resource that can either support local solutions or feed into grid?

**Step One: Modelling Demand**

BPS census data

BIG land-use data

- Desa boundaries/Population
- Existing Access
- PLN asset mapping

**Step Two: Demand Analysis**

PT PLN (PERSERO)

- Service standards, demand
- PLN Costs, O&M
- Cost/demand evolution

**Step Three: Analysis to provide Costs/Techs Timelines**

THE EARTH INSTITUTE COLUMBIA UNIVERSITY

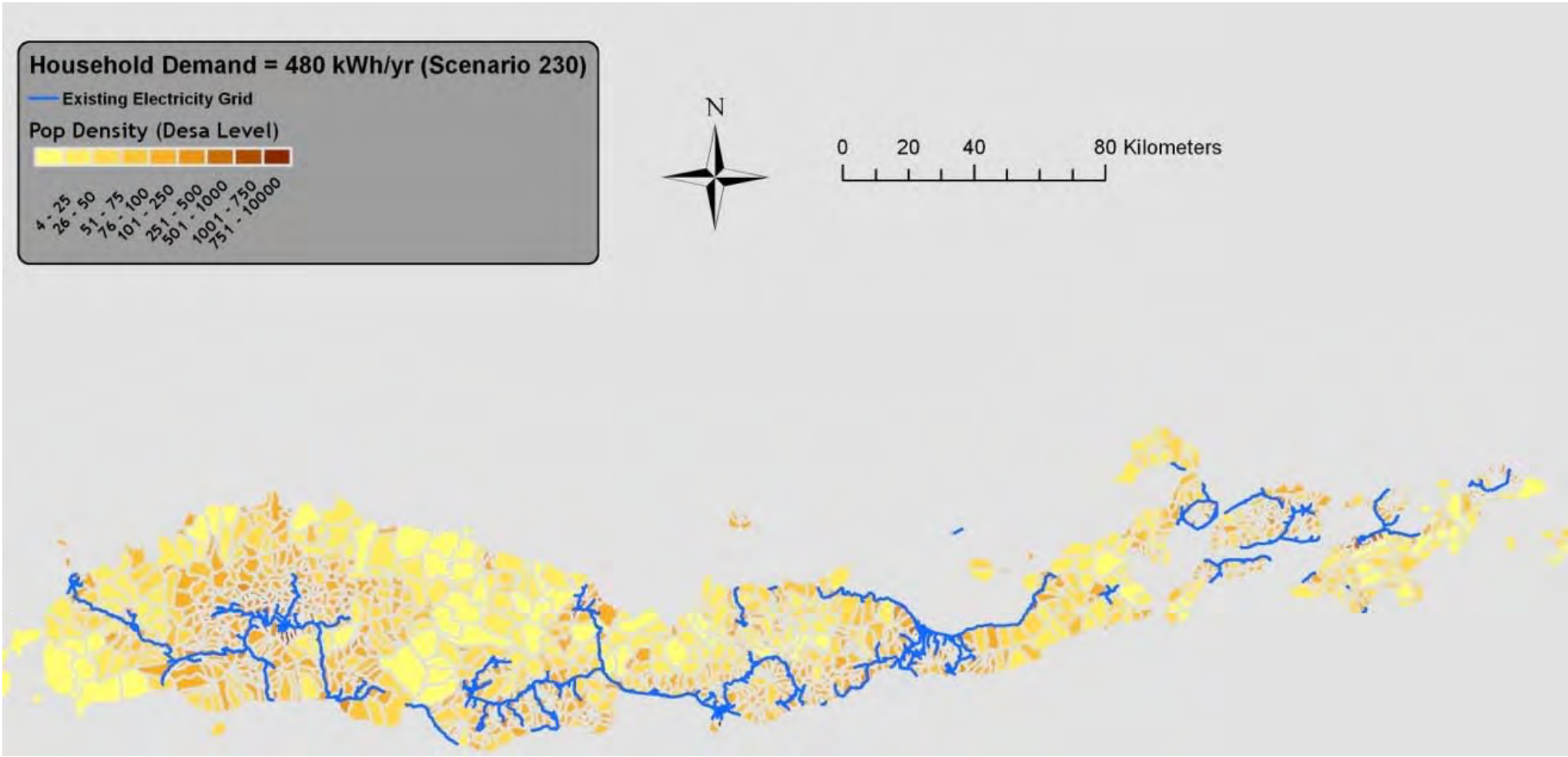
- Analyze for “least-cost” options to meet demands
- Visualize results, Big picture
- Platform for PLN to localize, adapt, iterate, share, update

**Step 4 Investment Plan**

**Castalia**
**World Bank**

# Flores with PLN Existing Grid

## (PLN provided GIS Medium Voltage Grid data)




170K/425K grid-connected; Where do those not connected live?

# Bakosurtanal/BIG Assistance

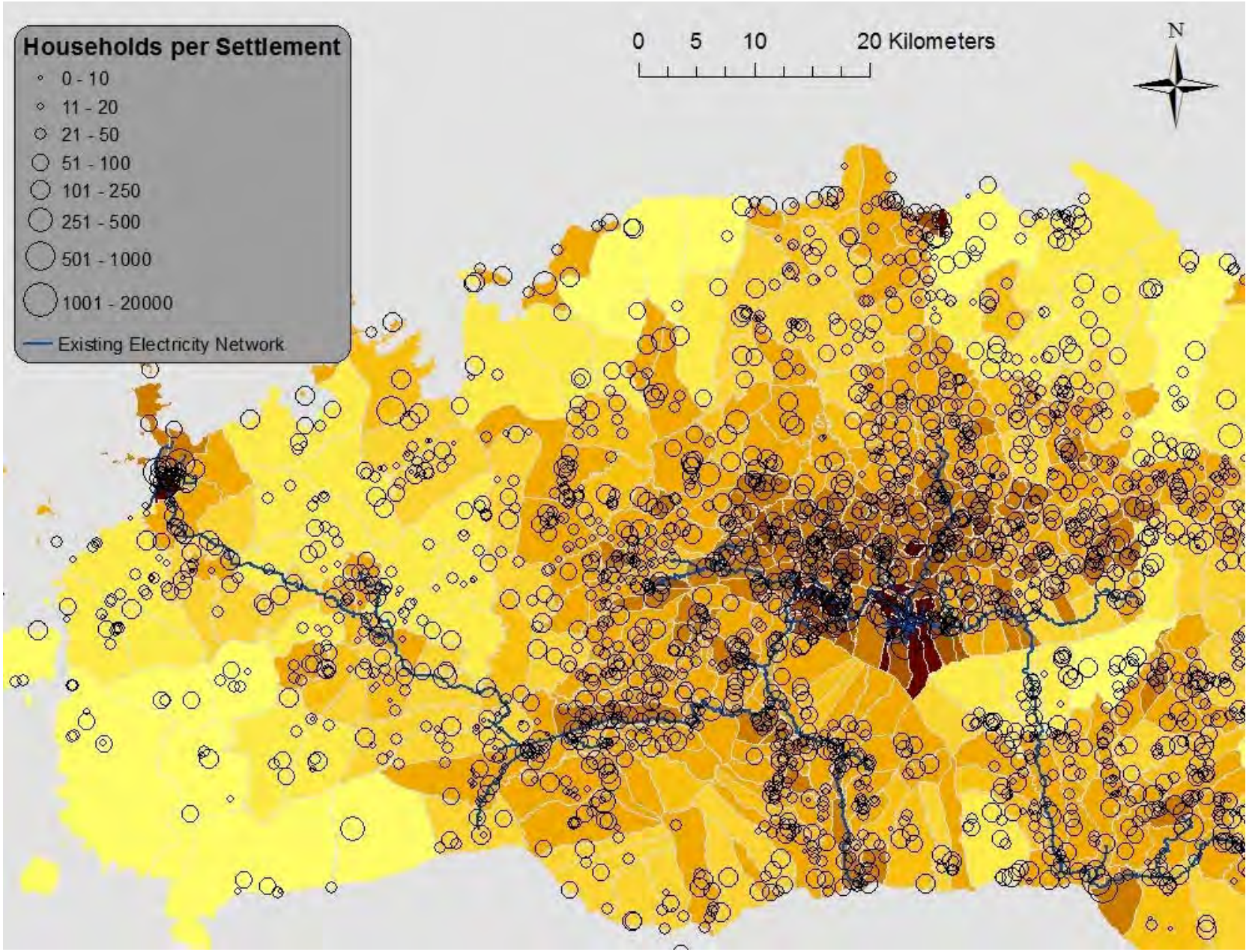
- BPS: Desa demographics
- Desa: Too large as a unit for electricity planning
- Model “settlement location/size” from “land-use”


Example Desa in Flores Island Group: Pondo, Lembor, NTT

# Settlements on Flores show small and tight clusters of land-use in wider landscape


Source: Badan Informasi Geospasial (formerly BAKOSURTNAL). P*enjualan Produk Hasil Survei Dan Pemetaan*. Retrieved November 2012

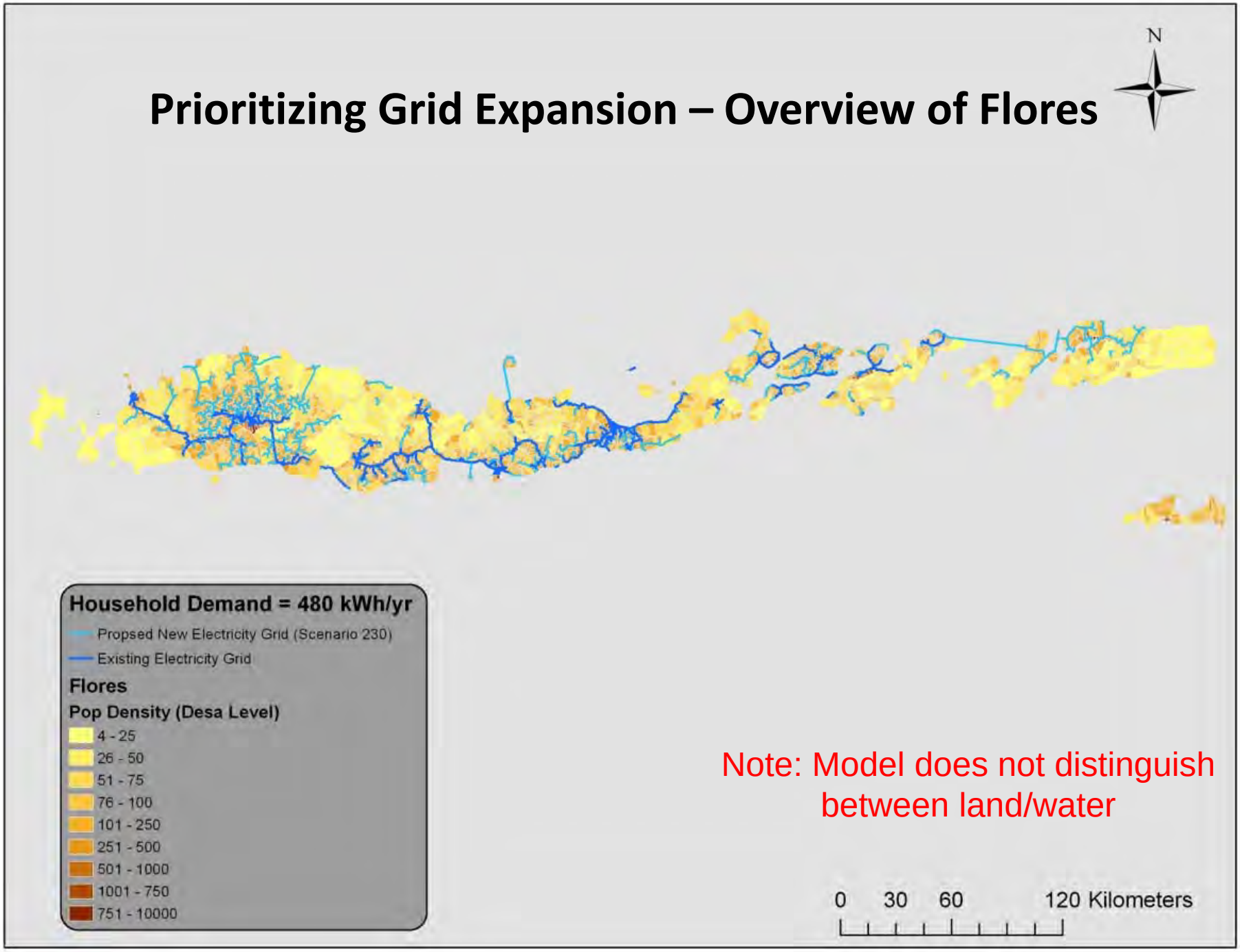
# Apply to entire island of Flores
# 6,300 settlements in 1,364 Desas (BPS 2010), 197 tiles (BIG)



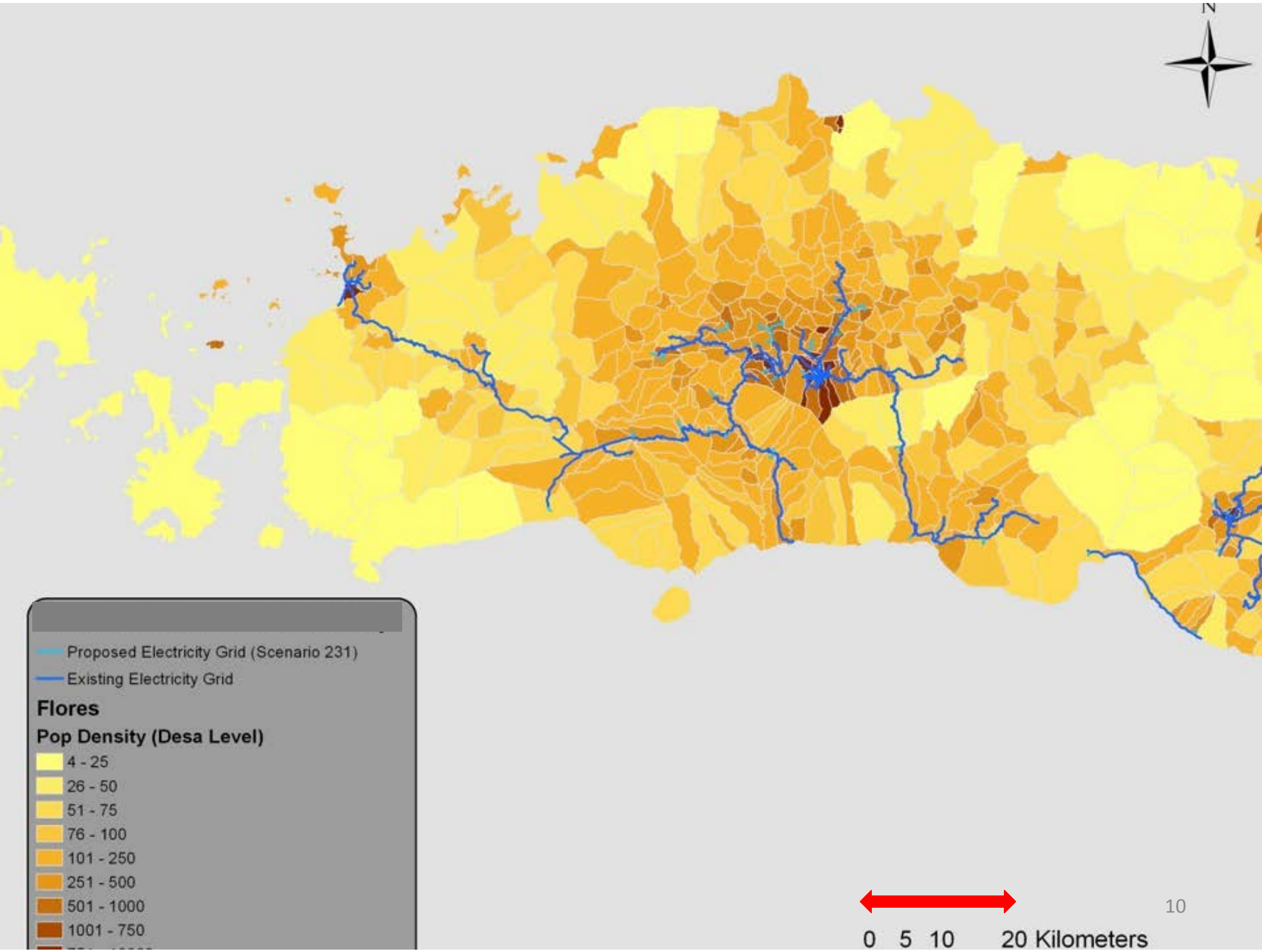
# Initial Analysis

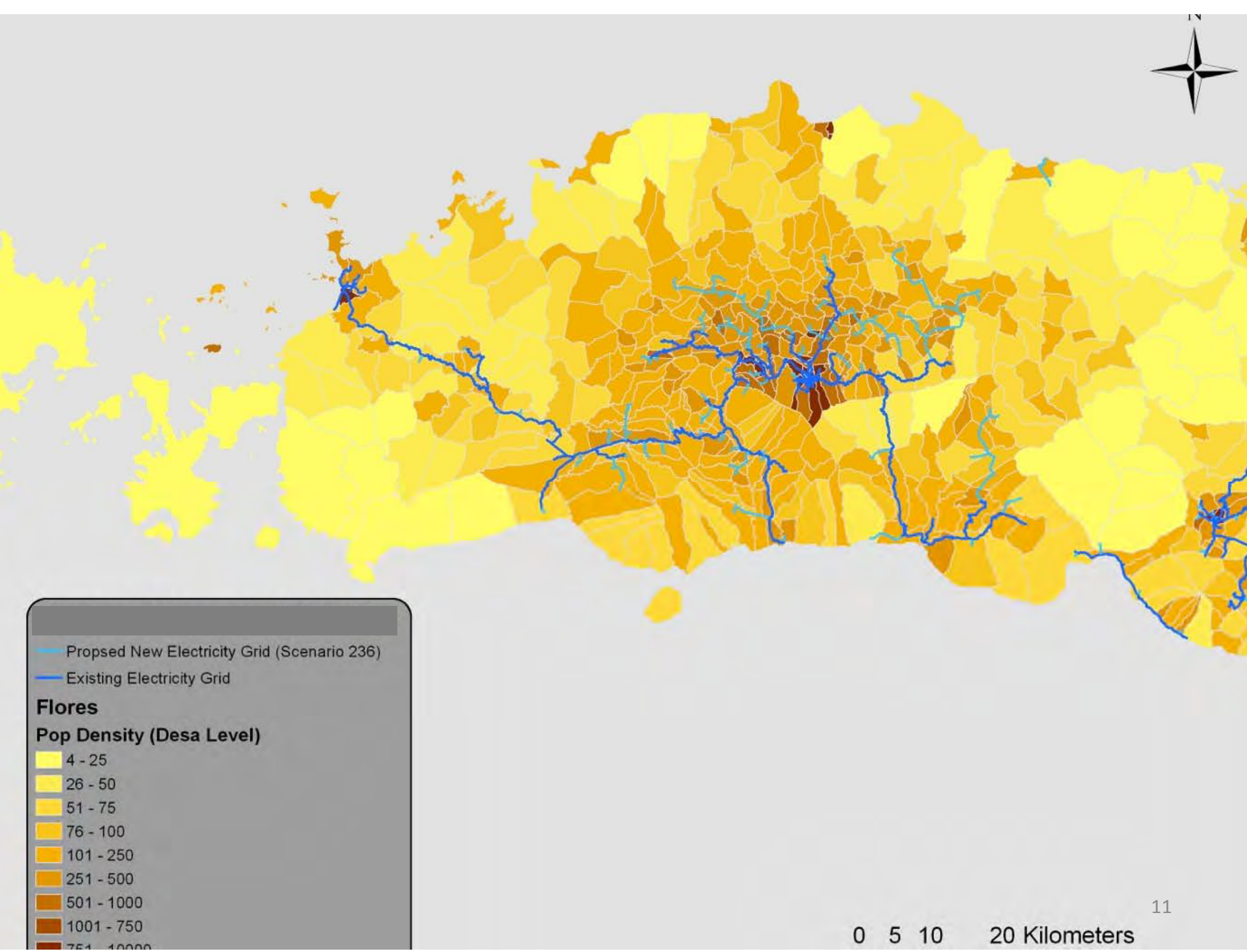
- Three technologies considered
  - Proposed Grid ( + Existing Grid )
  - Village Solar Mini-grid (incl: battery storage & possible diesel top-up, possible: “smart” op.)
  - Household solar (solar PV + battery)
- What tech is “least-cost” at each settlement, at 40 kWh/month per household
- When to deploy, allow demand growth

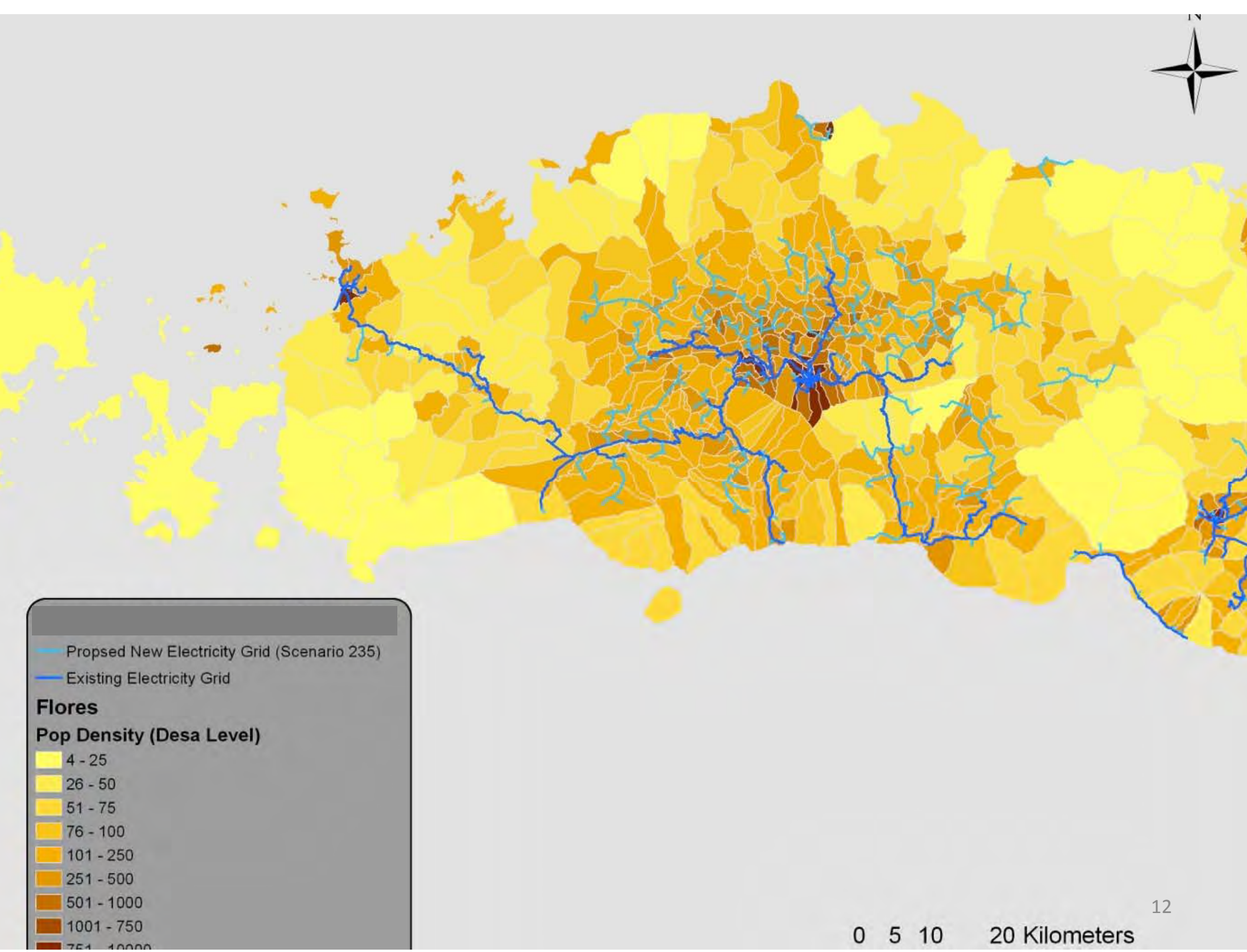
# Prioritizing Grid Expansion – Overview of Flores

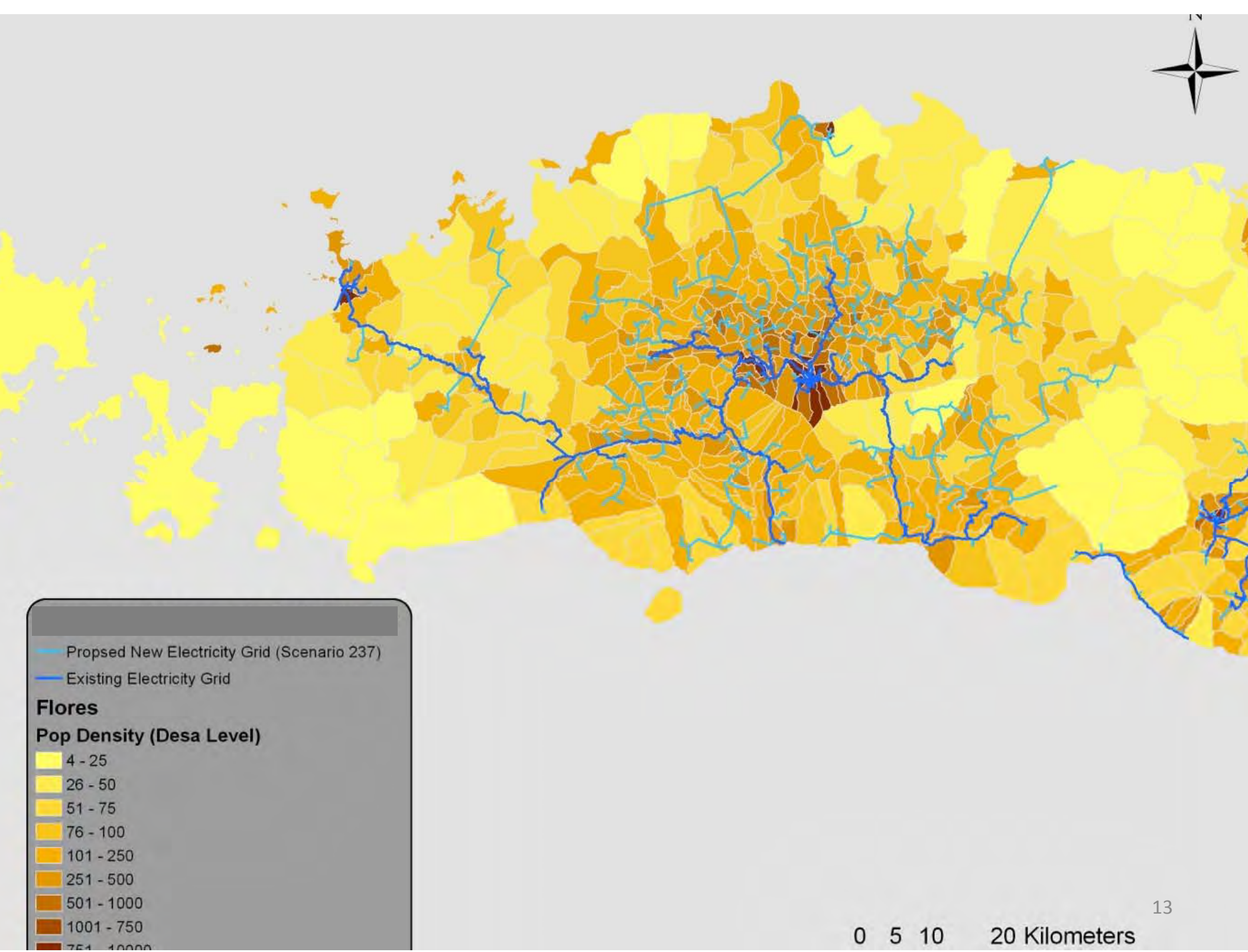


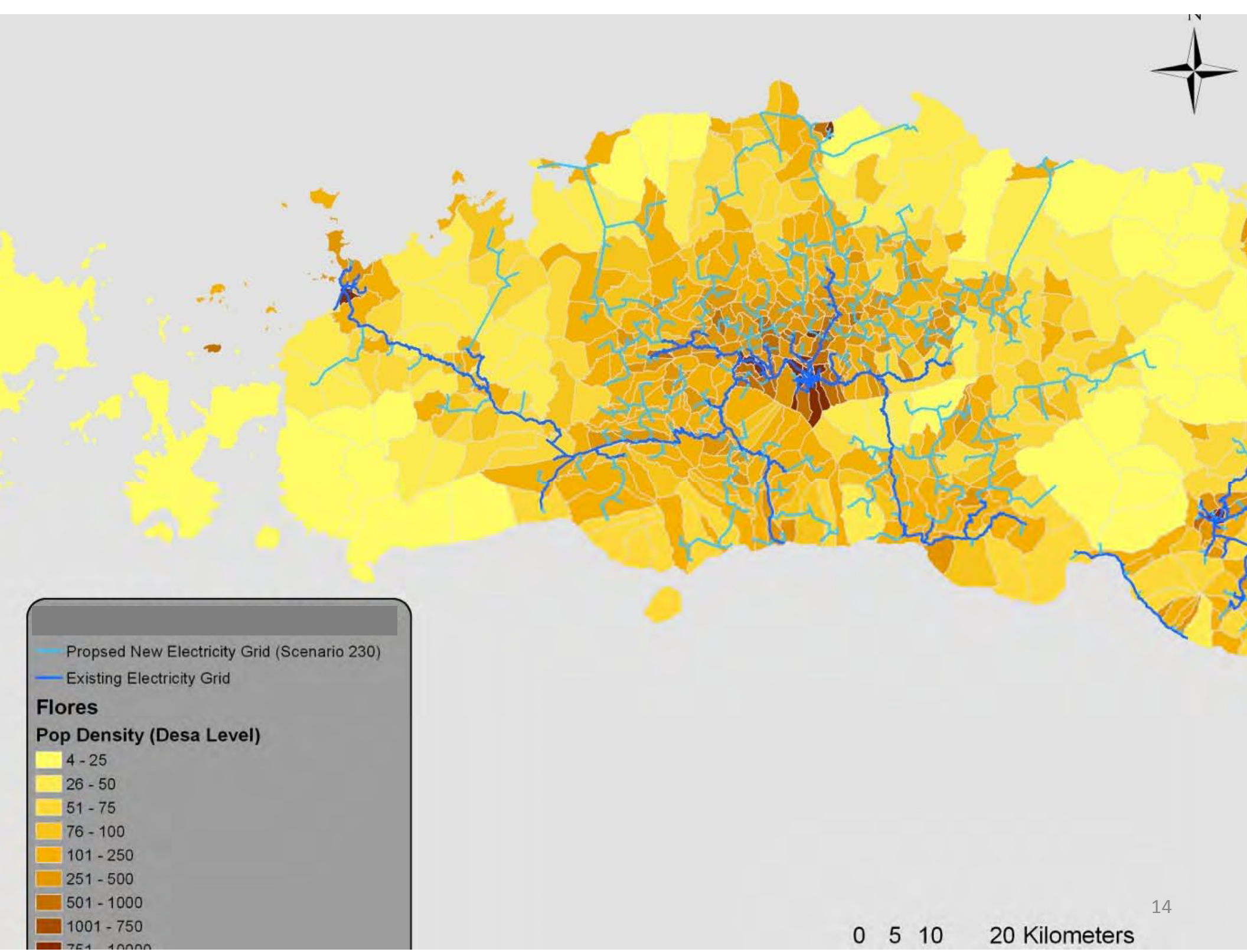

Note: Model does not distinguish between land/water

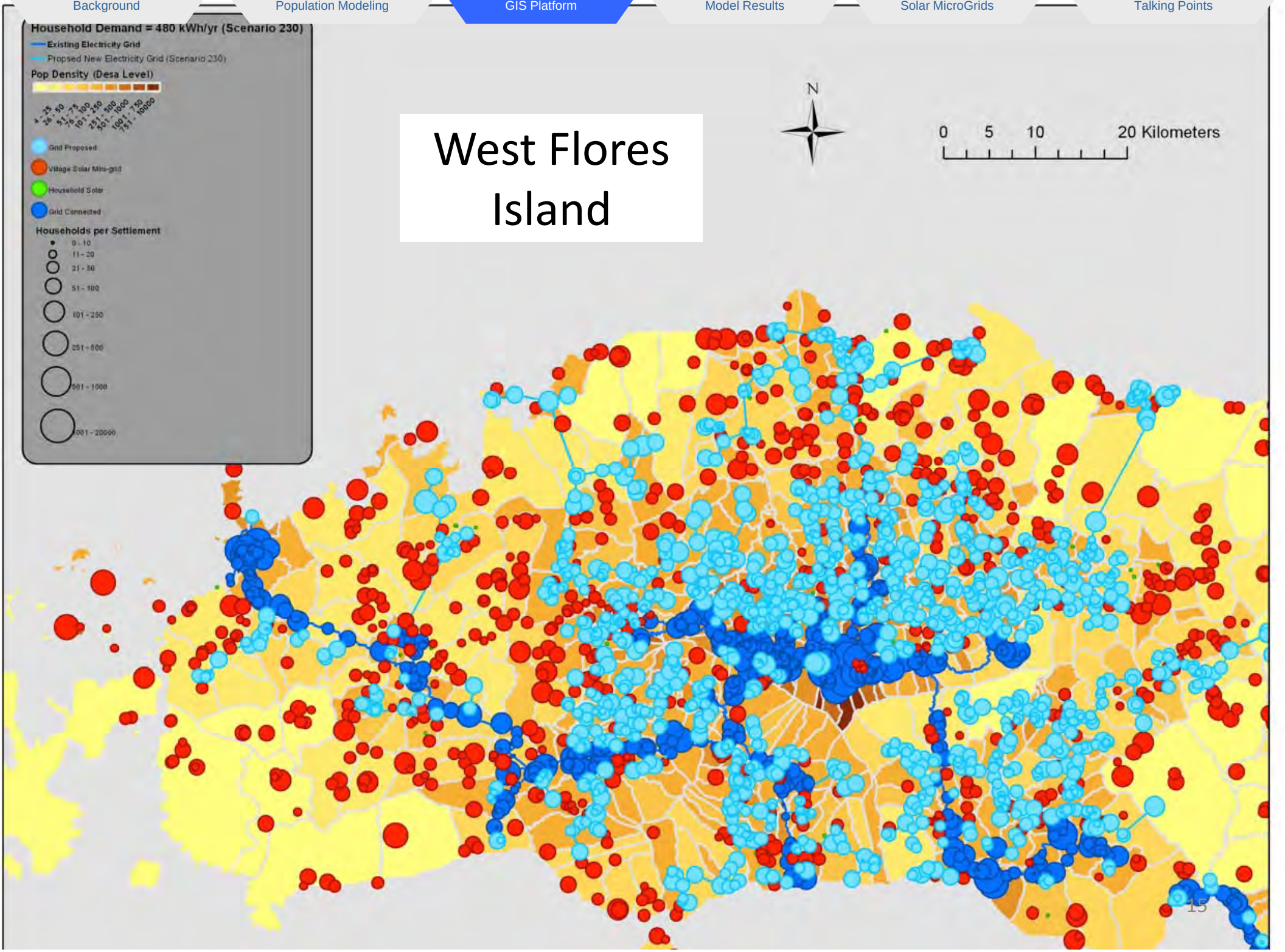

N
Proposed Electricity Grid (Scenario 231)
Existing Electricity Grid
Flores
Pop Density (Desa Level)
4 - 25
26 - 50
51 - 75
76 - 100
101 - 250
251 - 500
501 - 1000
1001 - 750
0 5 10 20 Kilometers

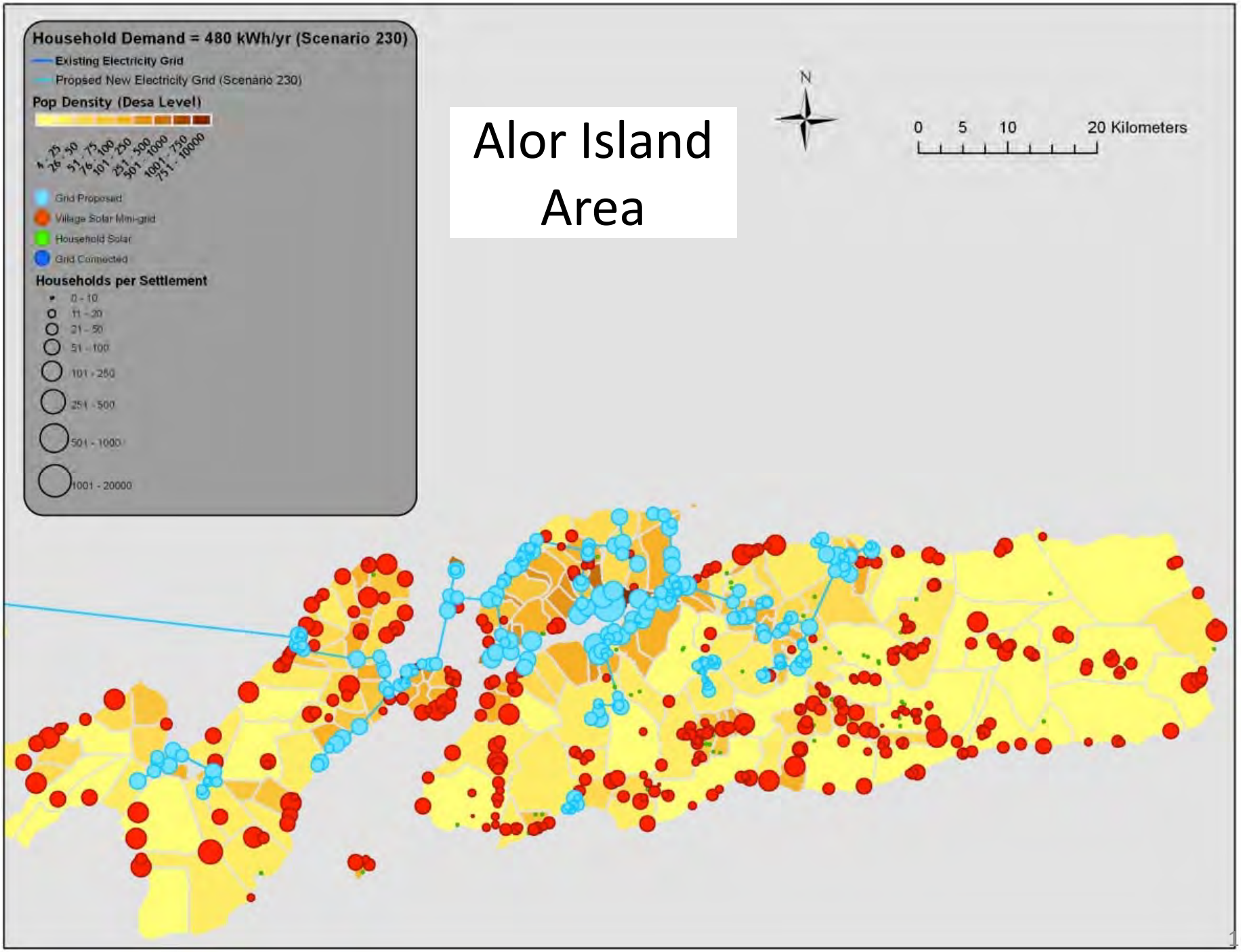

N
Propsed New Electricity Grid (Scenario 236)
Existing Electricity Grid
Flores
Pop Density (Desa Level)
4 - 25
26 - 50
51 - 75
76 - 100
101 - 250
251 - 500
501 - 1000
1001 - 750
0 5 10 20 Kilometers


N
Propsed New Electricity Grid (Scenario 235)
Existing Electricity Grid
Flores
Pop Density (Desa Level)
4 - 25
26 - 50
51 - 75
76 - 100
101 - 250
251 - 500
501 - 1000
1001 - 750
0 5 10 20 Kilometers

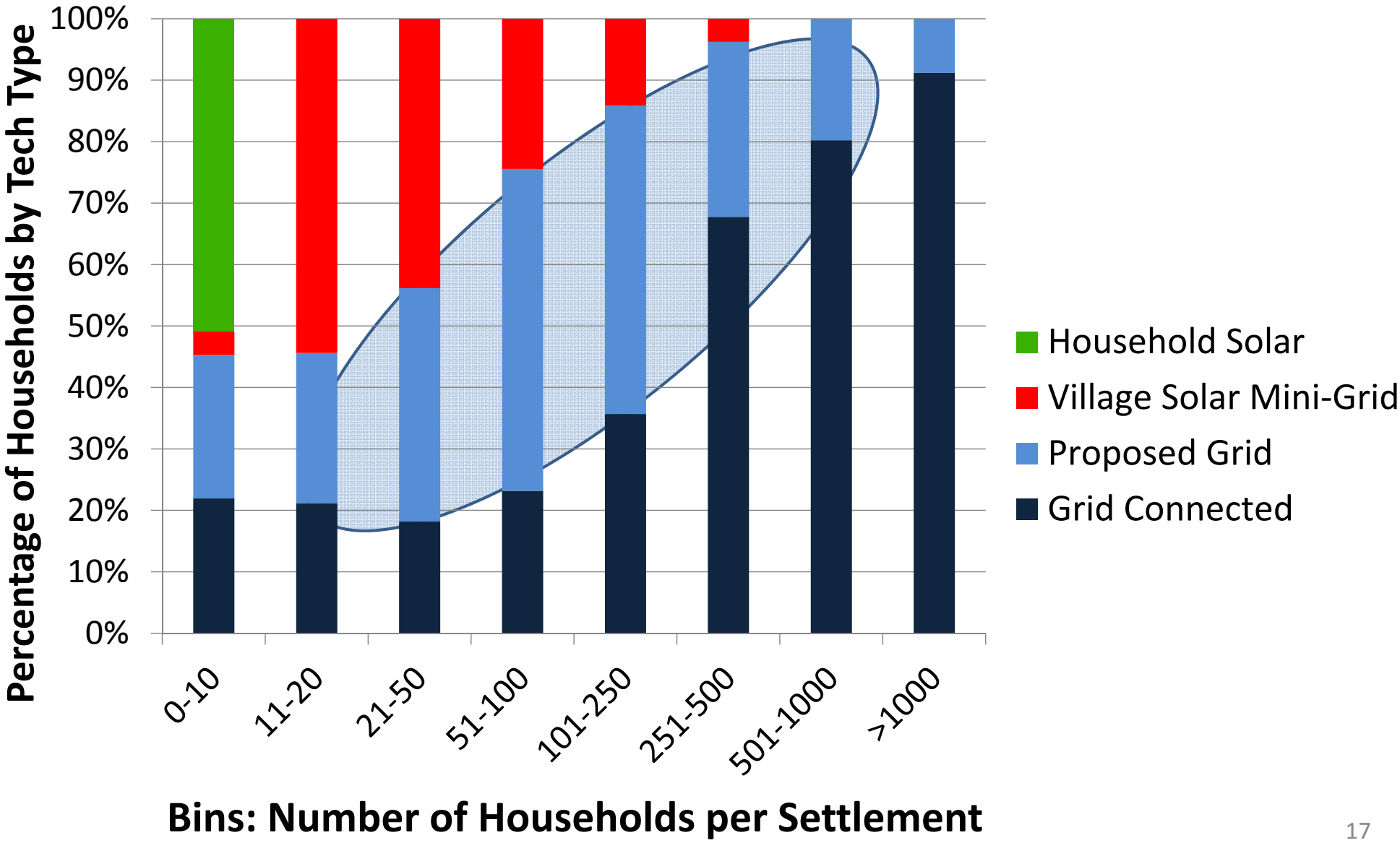

N
Propsed New Electricity Grid (Scenario 237)
Existing Electricity Grid
Flores
Pop Density (Desa Level)
4 - 25
26 - 50
51 - 75
76 - 100
101 - 250
251 - 500
501 - 1000
1001 - 750
0 5 10 20 Kilometers


N
Propsed New Electricity Grid (Scenario 230)
Existing Electricity Grid
Flores
Pop Density (Desa Level)
4 - 25
26 - 50
51 - 75
76 - 100
101 - 250
251 - 500
501 - 1000
1001 - 750
0 5 10 20 Kilometers

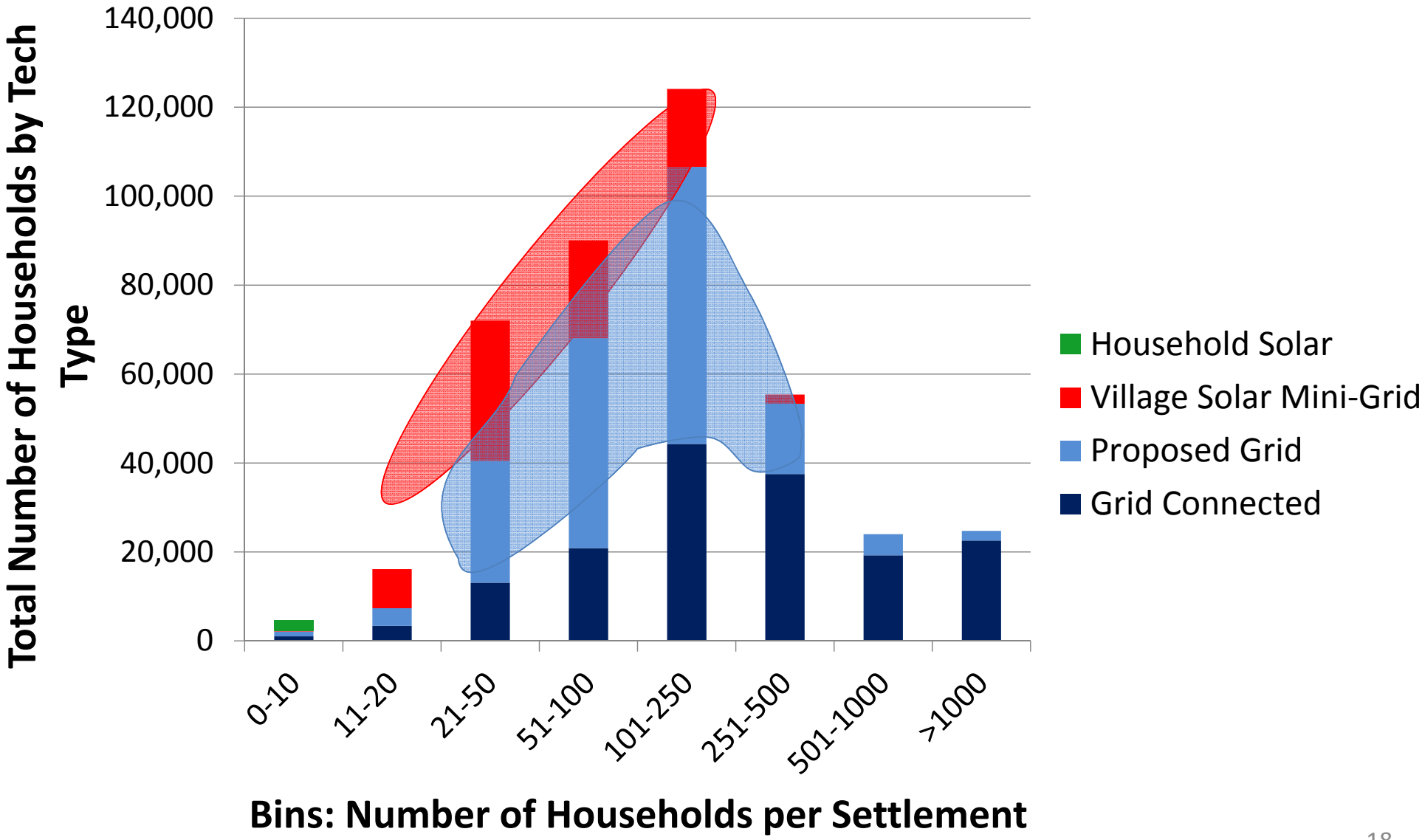

Household Demand = 480 kWh/yr (Scenario 230)
Existing Electricity Grid
Propsed New Electricity Grid (Scenario 230)
Pop Density (Desa Level)
1 - 25
26 - 50
51 - 75
76 - 100
101 - 250
251 - 500
501 - 1000
1001 - 750
751 - 10000
Grid Proposed
Village Solar Mini-grid
Household Solar
Grid Connected
Households per Settlement
0 - 10
11 - 20
21 - 50
51 - 100
101 - 250
251 - 500
501 - 1000
1001 - 20000
West Flores Island
N
0 5 10 20 Kilometers


Household Demand = 480 kWh/yr (Scenario 230)
Existing Electricity Grid
Proposed New Electricity Grid (Scenario 230)
Pop Density (Desa Level)
1 - 25
26 - 50
51 - 75
76 - 100
101 - 250
251 - 500
501 - 1000
1001 - 750
751 - 10000
Grid Proposed
Village Solar Mini-grid
Household Solar
Grid Connected
Households per Settlement
0 - 10
11 - 20
21 - 50
51 - 100
101 - 250
251 - 500
501 - 1000
1001 - 20000
Alor Island Area
N
0 5 10 20 Kilometers

# Grid “least-cost” expansion settlements



# Proposed Grid: 166,000 HHs
# Village Solar Mini-Grid: 84,000 HHs

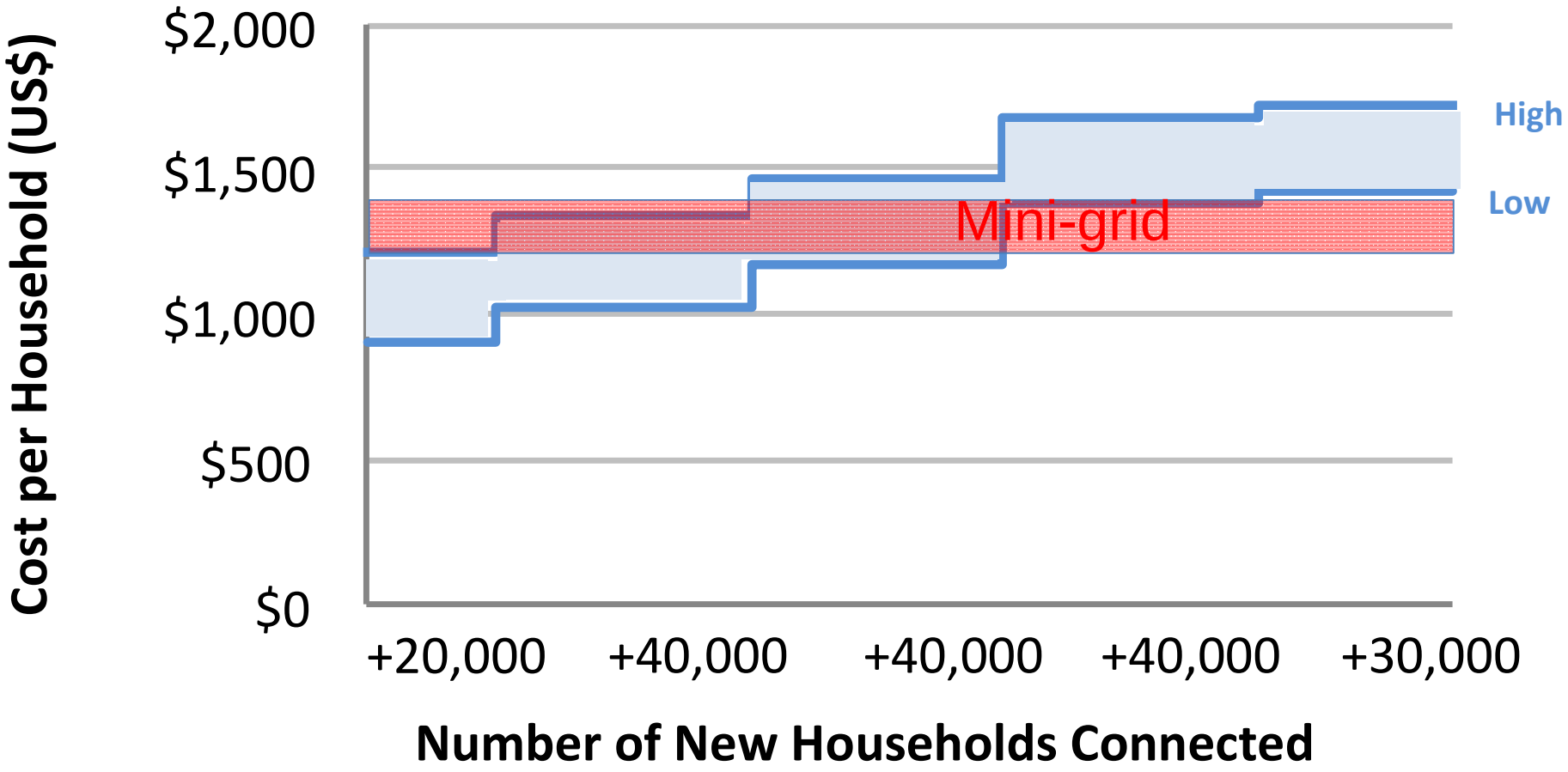


| Pre-Existing Grid: | |
|---|---|
| Pre-existing household grid connections (2010 Census) | 170,130 |

# Investments (250,000 new HH with elec)

| **Proposed New Grid Conn** | **165,000** |
|---|---|
| Total Initial cost for grid network (MV+LV) | $165 Million |
| | |
| **Village Solar Mini-Grids Conn** | **84,000** |
| Total Initial cost for all Mini-Grid systems | $94 Million |
| | |
| **Household Solar (model output)** | $5M for 3000 |
| | |
| Generation Costs for Grid Connected HH<br>Coal + Solar + Geothermal + Wind | |

# RE Mapping key to this cost curve



# What is the generation mix for the new 45 MW?

# RE Mapping is key to this mix

**able 1. Renewable Energy Potential in Indonesia**

| *nergy source* | *Installed capacity* | *Resource potential* |
|---|---|---|
| lydropower | 4,264.0 MW | 75,670 MW |
| Geothermal | 1,052.0 MW | 27,510 MW |
| Mini-hydropower | 86.1 MW | 500 MW |
| Biomass | 445.0 MW | 49,810 MW |
| olar | 12.1 MW | 4.8 kWh/m²/day |
| Wind | 1.1 MW | 9,190 MW |
| Ocean | 0.0 MW | 35 MW |

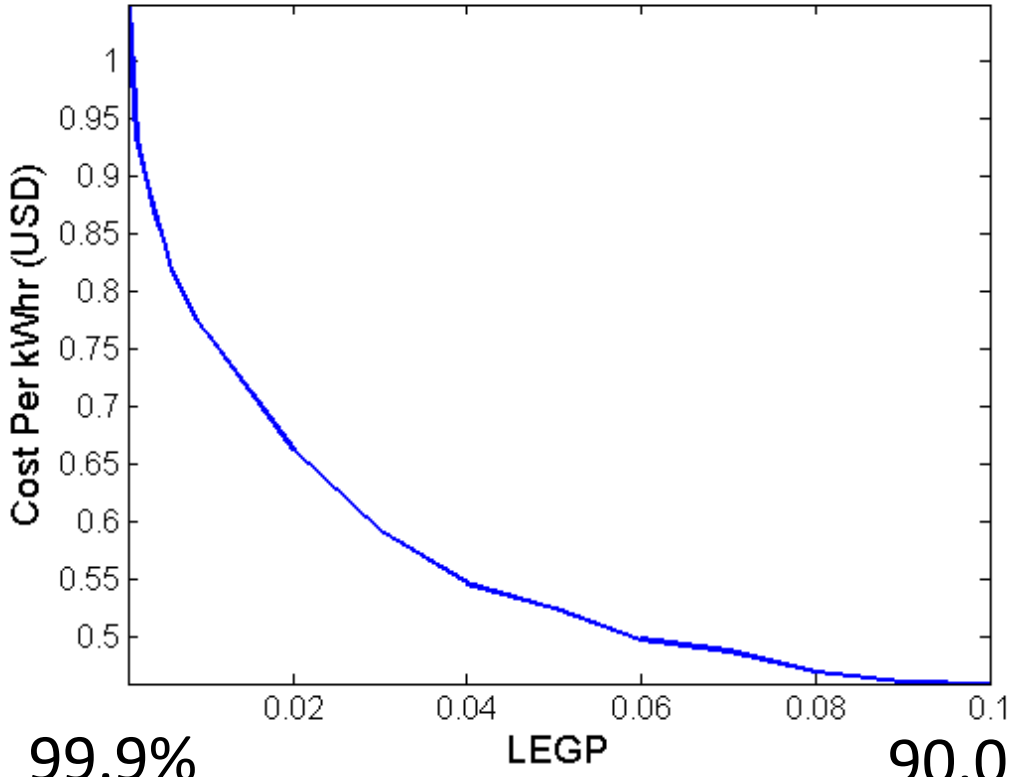
ource: PLN presentation to the United States Energy Association.

# Cost vs. Reliability Tradeoff in Solar Power:

## But needs to be done in context of local demand, economy and demographics

2 X

X




99.9% Reliability

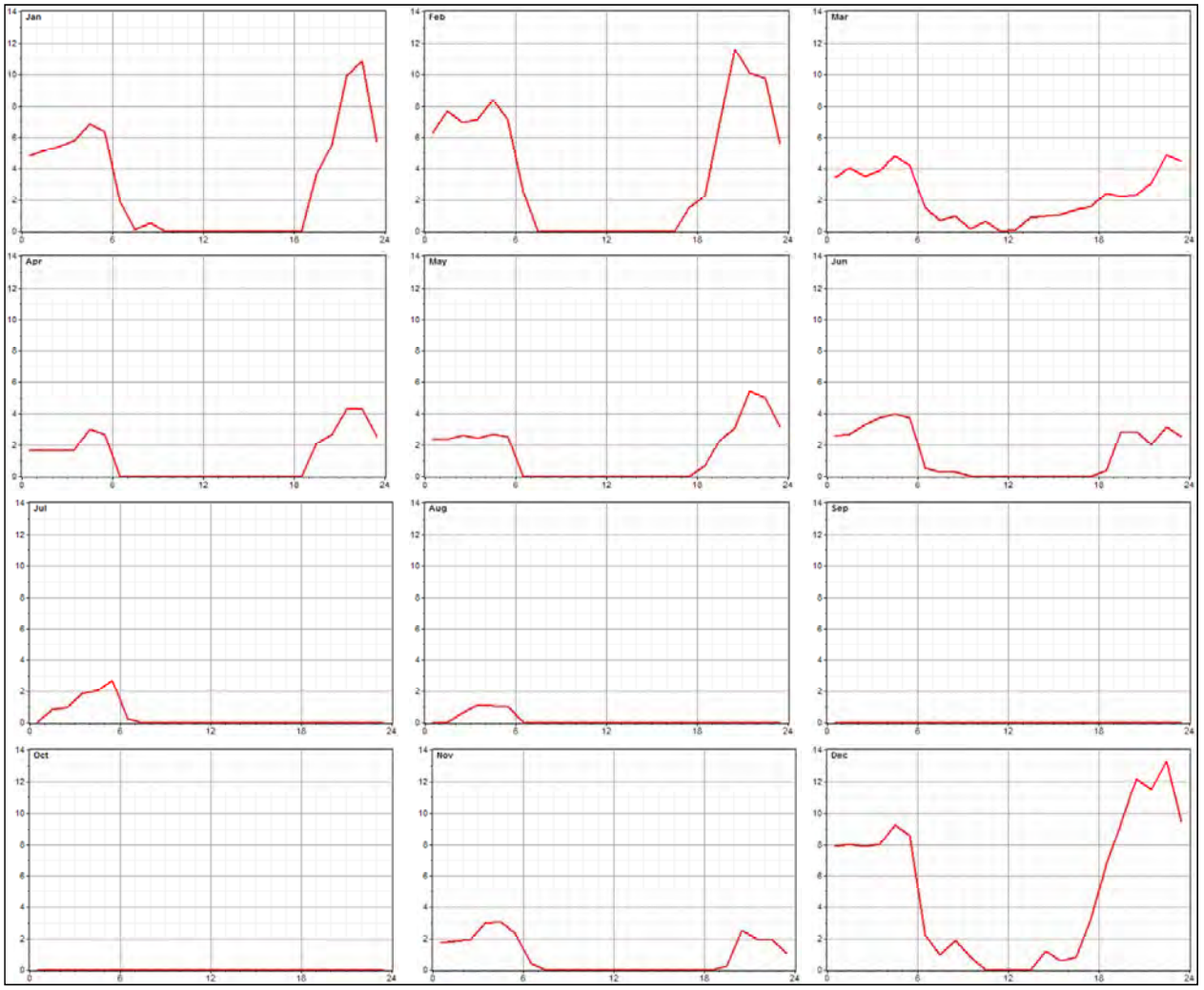
90.0% Reliability

| Reliability | PV Watts | Bat kWh | $/kWh |
|---|---|---|---|
| 99.9 | 4200 | 16 | 1.05 |
| 99 | 2500 | 13 | 0.76 |
| 97 | 2600 | 8.4 | 0.59 |
| 95 | 2000 | 7.8 | 0.52 |
| 90 | 1500 | 6.8 | 0.46 |

Cost in USD/kW·hr versus *LEGP* of micro-grid with refrigerator base load. The simulation uses the insolation profile from Segou, Mali. *LEGPs* range from 0.001 to 0.10. The cost for a reliability is the optimal combination of PV generation and battery storage which achieves that reliability. Thus, PV generation and battery storage capacity do not have a fixed ratio.

# PV only at 80 percent availability standards will (1) Lead to high customer dissatisfaction ...

Energy deficit 13-15 percent - Hours with deficit 18-21%




Similar or worse electricity unavailability in other sites

Lipu Village: Average Daily Unmet Load (kW) by Time of Day for Each Month

# Some big-picture observations

- Last mile of the unconnected customers to be electrified need more wire/customer
- Indonesia: Living in small clusters in islands
- Demands are not static and will grow
- So planning along with local renewable resource assessments quite important
- Utilities understand grids. Technical skills for mini-grid construction also within utility.

# Emerging techs/trends, relevance to PLN

- Privates ready for service-based contracts if done at scale, bulk procured, standards ensured & access to financing
- Islands in Indonesia can benefit from new models for mini-grids, autonomous diesel-free operation, smart storage management
- Leave it to local private to provide the last 1000 hrs of petrol/diesel backed reliability

Many thanks: BIG, PLN, Wilayah offices, WB, local teams

Longer term: embed these open-source tools in PLN