Multi-criteria tool to support decision-making of Electrification alternatives in Suriname

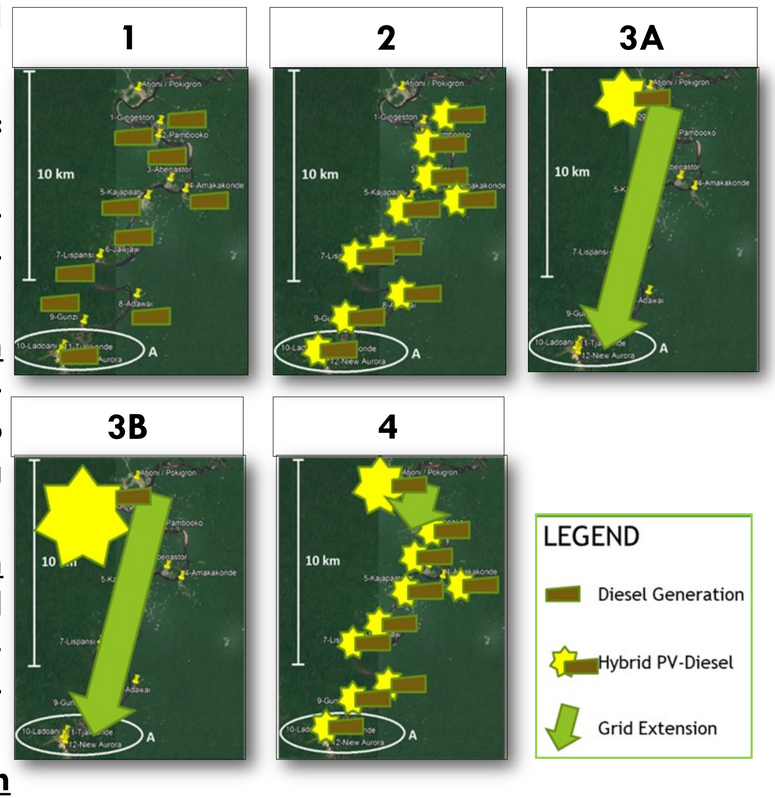
1. SCOPE AND OBJECTIVE

- Around 50 villages in the Upper Suriname River (South America) lack sustained electricity service.
- The sites are remote, demand density is low and potential clients have low income.
- Diesel generators owned and operated by the Ministry of Natural Resources supply free of charge, 6 h/d electricity.
- The Government (with EU and IDB funding) has planned to invest to purchase assets to provide 24/7 quality service.
- Several technological options are possible but the least cost analysis (LCOE) is not sufficient for an optimum selection
- **Objective:** to develop a multi-criteria evaluation matrix to support the decision-making to select the optimal technology for 12 villages.

2. ALTERNATIVE SCENARIOS

Consider 4 possible solutions and apply the evaluation to:

- **Scenario 1 (Diesel microgrids)**: conventional off-grid.
- **Scenario 2 (Solar Microgrids)**: PV-hybrid microgrids with battery storage, one per village
- **Scenario 3A (Grid Extension with additional 250 kWp)**: Grid extension (adding 250 kWp capacity to the existing PV-hybrid plant, for a total 750 kWp)
- **Scenario 3B (Grid Extension with additional PV "as required")**: Grid extension adding the optimum generation capacity of the existing PV-hybrid plant.
- **Scenario 4 (Mixed grid extension and solar microgrid)**: Grid extension limited by the capacity of the PV-hybrid plant (extended to a total 750 kWp), combined with PV-hybrid microgrids implemented in each of the remaining communities.



3. SPECIFICATIONS AND PERFORMANCE OF THE SCENARIOS

The different options have been defined based on existing data, the Utility's plans and, for Scenario 2, simulations of hybrid solar-diesel microgrid performance.

Scenarios	Unit	1	2	3A	3B	4
PV	kWp	0	2,035	750	1,200	1,890
Genset	kW	1,386	1,386	700	700	1,221
Converter	kW	0	1,186	500	500	1,021
Battery	kWh	0	11,320	5,000	5,000	9,828
Solar Fraction	%	0	94	47	67	93
Genset Generation	kWh/year	1,907,298	101,896	1,017,118	636,758	128,237
km of MV lines	km	0	0	21	21	6,7
CAPEX total	USD	1,492,194	8,159,946	9,314,884	10,017,528	9,813,476
OPEX	USD/year	1,263,310	537,497	555,137	472,173	597,155
LCOE	USD/kWh	0.72	0.63	0.70	0.69	0.689
CAPEX/ Connection	USD/ connection	1,034	5,655	6,455	6,942	6,801

Table 1—Summary of results of Scenario sizing and economic features

4. METHODOLOGY AND RESULTS

- Qualitative and quantitative indicators are defined. A MULTI-CRITERIA tool is designed for the quantitative criteria. Relative weights can be adapted.
- **A)** Quantitative assessment: the scores have been obtained using an analytical method based on the assessment of the 9 criteria, weighted and a chart to make comparative results visible.

				Scenario 1	Scenario 2	Scenario 3A	Scenario 3B	Scenario 4
	QUANTITATIVE EVALUATION CRITERIA	UNIT FOR CRITERIA	RELATIVE WEIGHT	NORMALIZED SCORE (1 for best)				
	FINANCIAL							
F1	CAPEX	USD	10.0%	1.00	0.18	0.16	0.15	0.15
F2	OPEX	USD / year	10.0%	0.38	0.88	0.85	1.00	0.97
F3	LCOE	USD / kWh	30.0%	0.88	1.00	090	0.92	0.92
	TECHNICAL							
T1	SOLAR FRACTION	% Solar Supply	15.0%	0.00	1.00	0.50	0.71	0.99
T2	SECURITY OF FUEL SUPPLY	$L_{Diesel\ Consumed}$ / year	15.0%	0.06	1.00	0.14	0.22	0.87
T3	TRANSMISSION LINE LOSSES	% Total Demand	10.0%	1.00	1.00	0.49	0.49	0.98
	ENVIRONMENTAL							
E1	CO_2 EMISSIONS GENERATED	$kgCO_2$ / year	4.0%	0.06	1.00	0.14	0.22	0.86
E2a	NOISE	Number of Gensets	0.5%	0.17	0.17	0.17	1.00	0.18
E2b		$L_{Diesel\ Consumed}$ / year	0.5%	0.06	1.00	0.14	0.22	0.087
E3	LAND USE	m^2 land-use	5.0%	1.00	0.01	0.00*	0.00*	0.00*

Table 2—Results of quantitative multi-criteria assessment (*0.00 score means that land-use score is much higher than for Sc 1 and Sc 2 and thus is out of the two-decimal scale)

B) Qualitative assessment: criteria that are evaluated are:

Technical: MV transformer losses, intrinsic safety, continuity of service, extending service beyond current analysis area, operational challenges (managing scattered generation projects), operational challenges (managing MV lines in the forest), construction duration.

Social: land rights, employment opportunities, satisfaction of community with infrastructure, knowledge required for O&M

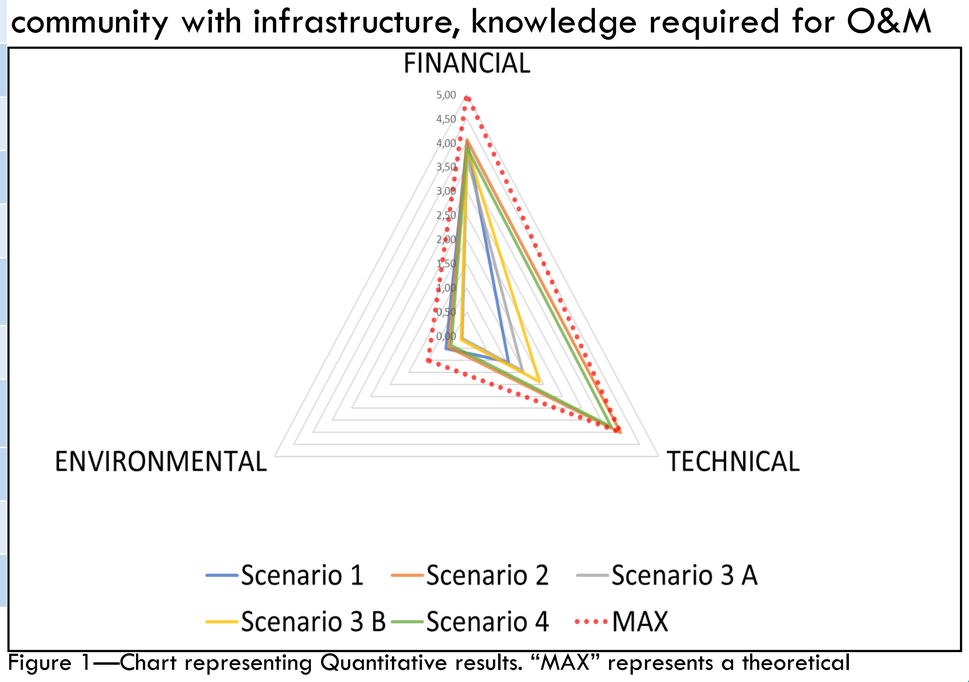


Figure 1—Chart representing Quantitative results. "MAX" represents a theoretical scenario which would score highest possible in all criteria. The closer the shape of the scenario to the MAX case, the better score it achieves

5. CONCLUSIONS

- **Scenario 2 Solar Microgrids** has the **highest score**.
- **Scenario 2** scores highest in the **Technological criteria**.
- **Scenario 2** has the lowest GHG from operation.
- **Scenarios 3A and 3B** have **higher CAPEX and LCOE** than Scenario 2 given the cost of grid extension installation and operation.
- **Scenario 2** has approximately **20 times lower land-use** than the grid extension scenarios 3A, 3B and 4 (although Scenario 1 scores highest in land-use)
- The best option resulting from the multi-criteria evaluation tool is a different scenario from the one initially foreseen.