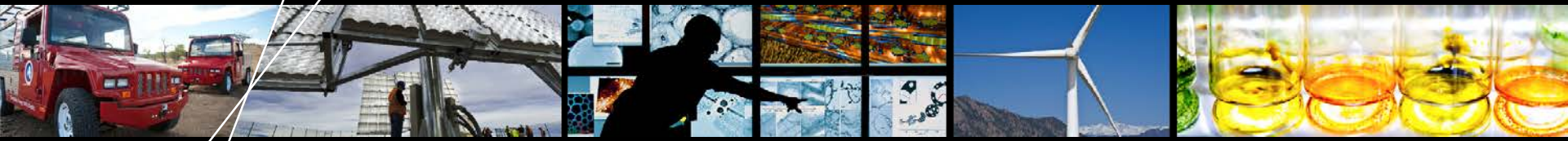
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

US DOE Project

Sustainable Energy for Remote Indonesian Grids (SERIG)

Stakeholders Workshop Oct. 1, 2014



Energy Efficiency and Renewable Energy Feasibility Study

Kari Burman, NREL

Outline

- Energy Efficiency Opportunities
- Renewable Energy Resources
- Renewable Energy potential at selected sites
  - Lamandau District
  - Sabu Island
  - East Sumba Hambapraing Next Steps
- Next Steps –Open Discussion

Lamandau District & Sabu Island

Electrical Capacity

Electricity Data	Lamandau	Sabu Island
Number of diesel plants (PLTD)	3 (in different locations)	1
Number of diesel engines	PLTD AMP: 4 PLTD BKSB: 3 PLTD Nanga Bulik: 2	8
Actual capacity (kW)	PLTD AMP: 2,400 (24 hrs) PLTD BKSB: 1,000 (12 h/d) PLTD Nanga Bulik: 800 (5 h/d)	1,470
Installed capacity (kW)	4,000	1,650
Day load (kW)	Approximately 2,000	580
Night load (kW)	Approximately 3,000	900
Distance to 20 kV line (km)	< 0.5	< 1
Number of PLN customers (household) (2012)	6,449	3,633

Energy Efficiency Assessment

Electricity usage

- 75% in residential,
- 20% in commercial sector
- 5% in home industry and others

Type	Description	Quantity	Power (Watt)
Lighting	compact fluorescent	3–4	13, 26
Television	21-inch, cathode ray tube	1	120
Refrigerator/Freezer	4.5–6 cubic feet capacity	1–2	150
Water pump	electric shallow well pump	1	125
Fan	12-inch, 3-speed table fan	1	100
Rice cooker	10-cup rice cooker and warmer	1	400
Clothes washing machine	5-kg, top load	1	500
Water dispenser	5-gallon	1	200-400

Domestic consumption by household

- 70% in lighting
- 30% in TV, cooling and other household appliances

Energy Efficiency Assessment

Diesel Generators

- Leased generators – good condition
- Local district government owned – fair to poor condition
- Require operator skills in operation & maintenance (O&M)
- Low efficiency due to conditions

Opportunities

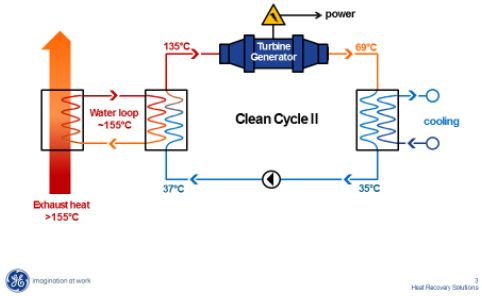
- Generator replacement
- Waste heat energy recovery
- Improved O&M
- Substantial potential savings (> 10%)

Energy Efficiency Assessment

Promising EE technologies for remote grid areas

- **LED lighting**
- **Energy Star appliances - LCD/LED television, clothes washing machine, refrigerator/freezer, and fan**
- **High seasonal energy efficiency ratio (SEER) air conditioner for high-end consumers, businesses**
- **High to premium efficiency motor**
- **Diesel generator efficiency and waste heat recovery (Organic Rankine Cycle)**
- **Hybrid diesel and renewable energy electricity generation**
- **Improve operation & maintenance of diesel generators and operator s**

The organic rankine cycle



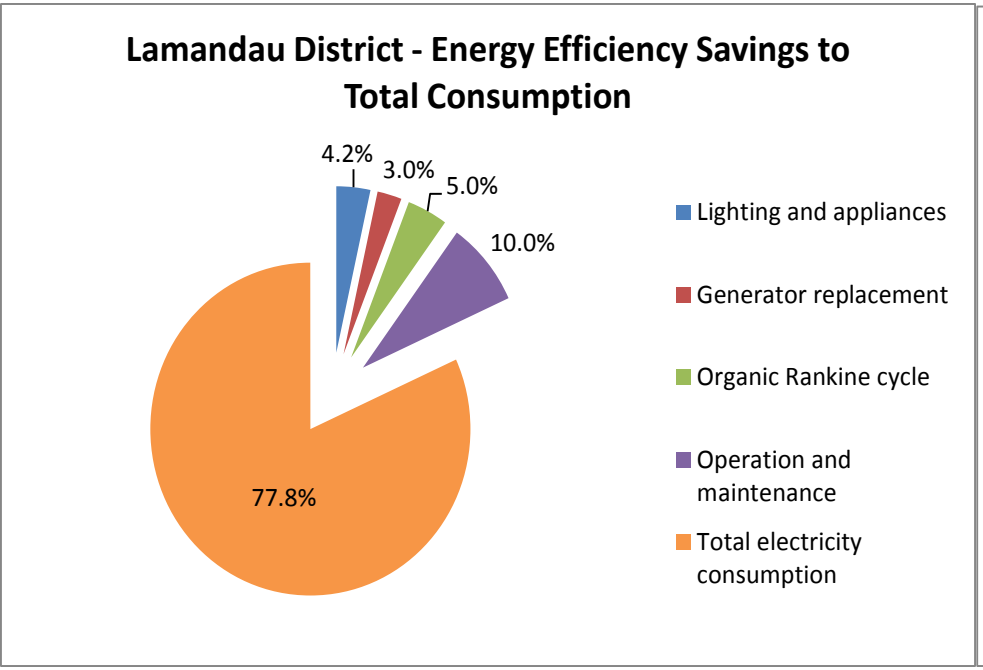
Energy Efficiency Assessment

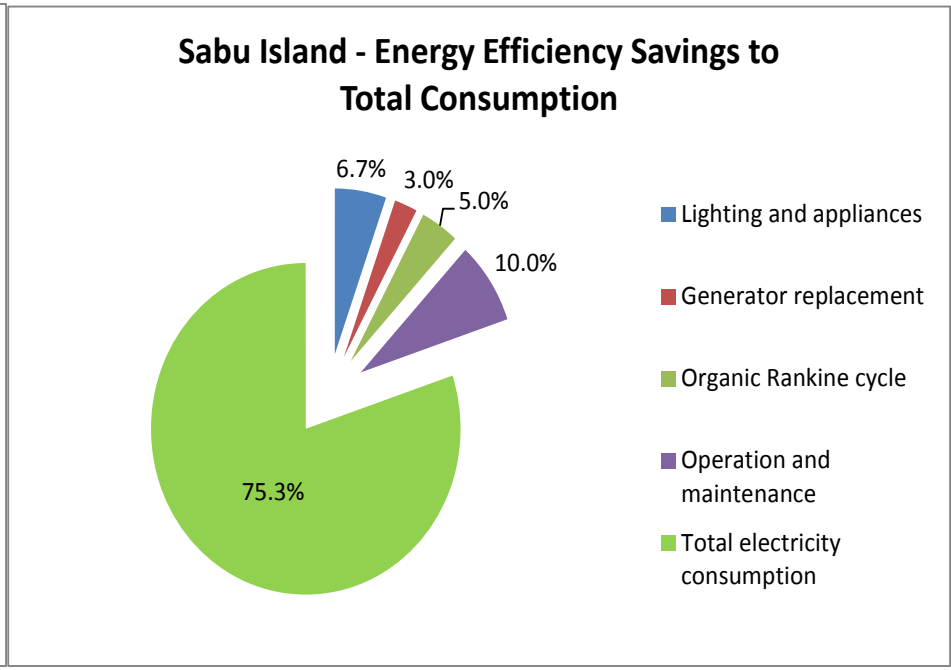
Lamandau District

- 22.2% energy savings
- 3,596,034 kWh/yr
- 952,949 liter/yr of diesel fuel
- 2,554 tCO_2/yr reduction

Sabu Island

- 24.7% energy savings
- 1,144,357 kWh/yr
- 303,255 liter/yr in diesel fuel
- 813 tCO_2/yr reduction



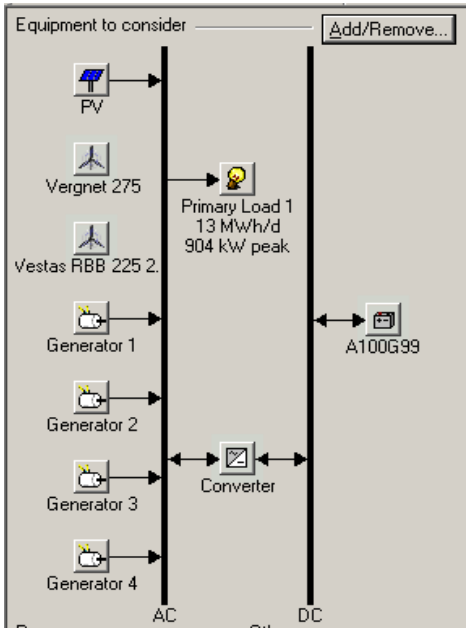


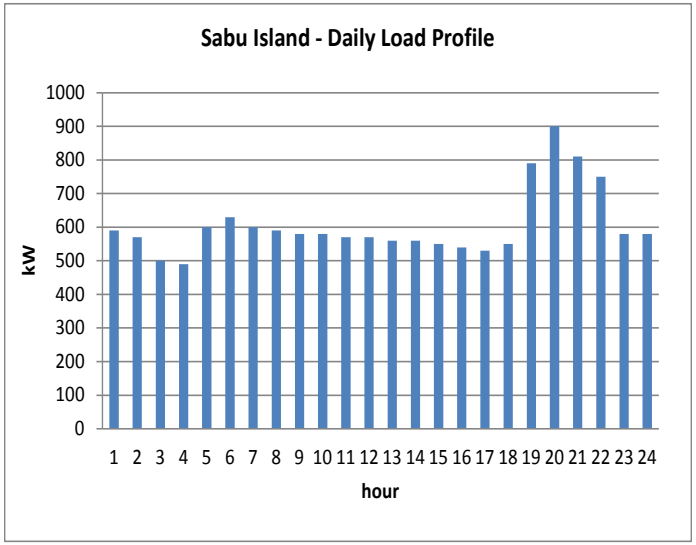
Lamandau District, Central Kalimantan

Renewable Energy Assessment

Methodology

- Collected and evaluated load and exiting generation data
- Used HOMER model to evaluate potential RE scenarios based on resource and cost data
- Optimize System mix based on Net Present Cost and Levelized Cost of Energy (LCOE)
- Compared base case with potential renewable energy scenarios





Renewable Energy Assessment: Lamandau District

Opportunities for RE include PV and Methane Capture from Palm Oil Mill Effluent (POME)

POME from four palm oil mills in Lamandau potentially could generate about 7 MWe.

Two palm oil mills which are close to PLTDS (i.e., PT Gemareksa Mekarsari and PT Nirmala Agro Lestari (NAL)) could produce 3.5 MW

No	Company	Production Capacity (ton/hour CPO)	Total Energy Potential from POME[(a)] (MWe)	Estimated Generation Capacity from EFB, Shell & Fiber[(b)] (MWe)
1	PT First Lamandau Timber Int.	45	1.52	10
2	PT Pilar Wana Persada	60	2.03	
3	PT Gemareksa Mekarsari	60	2.03	
4	PT Nirmala Agro Lestari	45	1.52	
	TOTAL	**190**	**7.08**	**10**

Source: Dinas Kehutanan dan Perkebunan, Lamandau, 2013

(a) Assumption: FFB to POME ratio: 70%, COD level: 55,000 ppm, operating hours: 6,000 h/year, and COD removal of 80%. Source: Estimated from data in Dinas Perkebunan, *Provinsi KalimantanTengah* (2011).
(b) Estimated based on the assumption that the electricity generated has a capacity factor of 80% and that operating hours of the mills are 8,760.

Renewable Energy Assessment: Lamandau District

Adding Biogas from two Palm Oil Plants to diesel power plant

- Adding 2.5 MW biogas from POME would decrease diesel fuel usage by 98 % and decrease the LCOE by 70%
- Challenge to adding biogas from Palm Oil plants is the added cost to capture the methane and add transmission lines
- The advantage to adding Biogas is to diversify the electrical power generation, reduce diesel fuel use significantly and provide dispatchable power 24 hours 7 days per week (much like diesel)

Renewable Energy Assessment: Lamandau District

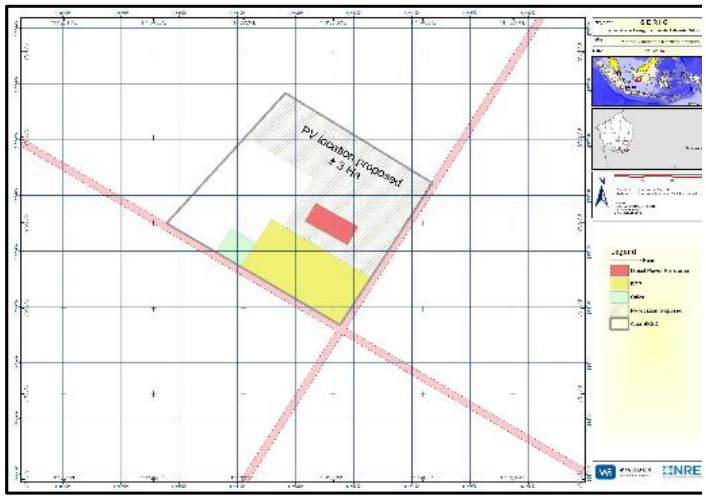
Adding PV system to diesel power plant

- Adding 1 MW PV would decrease diesel fuel usage by 9% and decrease the LCOE slightly (0.4%)

- Challenges of PV systems is they have variable generation and are not dispatchable. PV power is only available during the day while peak loads are generally at night

Hybrid Power system

A hybrid system : Biogas (1.5 MW) from palm oil mills and
PV (1 MW) could reduce diesel fuel usage by 37% and reduce LCOE by 50%




Sabu Island - NTT

Renewable Energy Assessment: Sabu Island

Opportunities for RE include: PV, Wind Turbines and Storage

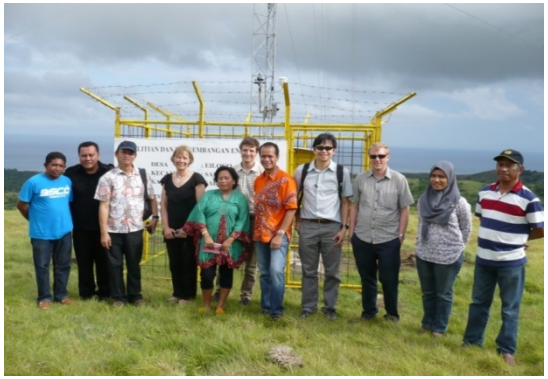
- **Photovoltaics (PV)**

  Good solar resource for utility scale PV
  Daily average solar insolation on Sabu > 6 kWh/m2/day

- **Wind resource**

  There are two sites that have an estimated average wind speed > 7 m/s
  Both sites are close to the 20-kV grid

- **Storage: Deep-cycle Lead-acid Batteries**
  - **wet cell** or **flooded** batteries require distilled water to be replaced on a regular schedule
  - valve regulated (**VRLA**) have less maintenance
  - batteries in electrical systems must be **deep-cycle**; i.e. discharge a large amount of energy in one cycled



Renewable Energy Assessment: Sabu Island

Adding PV system and storage to diesel power plant

- Adding 250 kW of PV and 72 batteries (553 kWh) storage would decrease diesel fuel usage by 20% and decrease the LCOE by 14%
- Challenges of PV, battery systems is higher maintenance cost and technical expertise to operate
- The advantage to adding solar PV and batteries to diversify the electrical power generation and provide less dependence on diesel fuel

Renewable Energy Assessment: Sabu Island

Adding Wind turbines to diesel power plant

- Adding 2- 275 kW Vergnet turbines is most cost effective and can decrease the diesel fuel by 30% and decrease the LCOE by 13%
- Challenge to developing wind projects include: Permitting, construction access and transportation of large cranes
- The advantage to adding wind turbines is to diversify the electrical power generation, reduce diesel fuel use significantly and provide more additional power to the generation mix.

East Sumba Hambapraing Grid Connected Wind Project

Role SERIG:

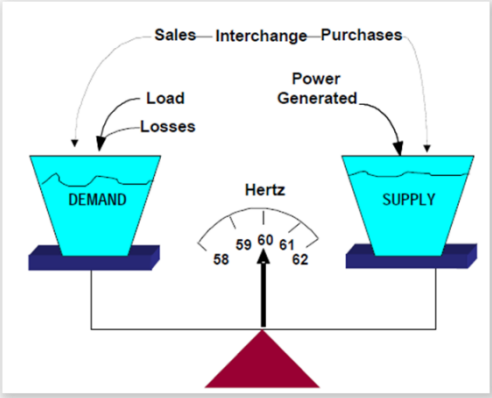
- Provide TA on grid integration of WTG in East Sumba grid.
- Support implementation

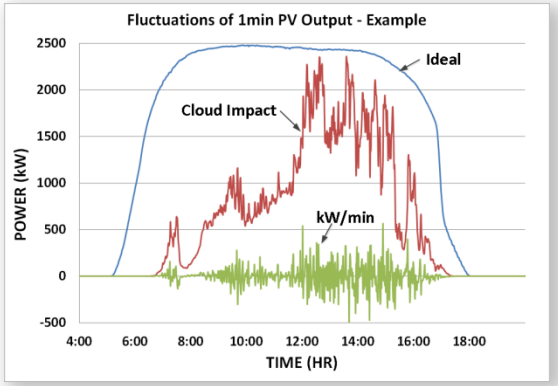
- Objective: Wind Pilot +/- 500 kW
- Scale up to 4 MW
- Wind Measurement; 2+ years
- Part of 'Iconic Island' initiative
- Funded by HIVOS
- Cooperation with Private Sector
- Timeline: 2015 Pilot Project

Grid Integration on Islands

Integrating Intermittent Renewables on Island Grids

- **Islands typically have a weak electric grid (compared to mainland) making integrating RE challenging. However, cost of energy on islands is high so economics are usually favorable**
- **Renewable Energy Penetration**
  - Definition is: Rated power from RE vs peak load
  - Inter-connect large variable generation from RE onto small grid
  - Without storage diesel generators must cover the resource variability
  - Impact depends on the design and penetration level
- **Impact Studies**
  - Power Flow analysis
  - Dynamic modeling/ stability analysis
  - Short Circuit and protection coordination study





Recommended Plans and Activities – Renewable Energy

1. **Planning**
   - Develop a renewable energy roadmap at the district level for Lamandau district and Sabu Island
     - The analyses shows that adding PV, biogas, wind, and storage where appropriate can reduce LCOE and reduce fossil fuel use
     - Additional techno-economic analysis could more precisely identify costs and benefits associated with each configuration
     - Determine a time line for projects

2. **Renewable Energy Projects and Programs**
   - Identify opportunities and priorities for renewable energy technologies with greatest potential impacts
   - Encourage renewable energy project:
     - Subsidizing the price of renewable energy technologies and products like PV panels
     - Work/partner with local suppliers and retailers to source RE technologies

3. **Funding and Financing**
   - Engage investors
   - Additional economic modeling should be done for the biogas plants

4. **Training and Outreach**
   - Expand capacity building for human resources in operation and maintenance of hybrid power systems
   - Provide technical assistance to develop further analyses of energy savings and cost effectiveness of renewable energy technologies

Next Steps and Future Work for SERIG

- Further refine best set of renewable and energy efficiency opportunities through additional data collection, analysis, and stakeholder consultation
- Begin to identify financing partners, off-takers, and technology providers
- Develop deployment plan that optimizes EE and RE opportunities
- Develop replication strategies

What should our next steps be?

Open discussion for your ideas!

Terima kasih!

Thank you!