Introduction – Motivation

Objective – Analyze the reliability of a remote wind-diesel microgrid system as demand grows over a period of time.

Method – Estimating Load data
– Determine wind power generated given wind speeds
– Transmission system layout
– Power flow modeling and simulation in MATLAB.

Results – Quantify system reliability

Introduction

– National grid electricity supply to low density areas results in high capital outlays, large transmission losses and less reliable electric services.

– Rural Electrification Programs can be better achieved through wind-diesel microgrids.

Dominant energy source for non-electrified households is wood fuel.

Associated with adverse health and environmental effects.
Objective

- Model a wind-diesel system and analyze its reliability as load increases over a period of 8 years
  - Based on the % of wind energy predicted to go into the system compared to the actual % from the wind energy output curve at the same load level as that of the power flow model.
- Investigate the impact of varying the diesel generator unit size on the contribution of wind energy to the system.

Case study: Marsabit, Kenya

- Population of 37,445 people.
- Trading and Commercial Centre.
- Grid ends 263 km from Marsabit.

Load Data Analysis

- Based on a survey was done in Fatick, a rural village in Senegal to determine the daily energy demand per household.
- Load analysis broken down into four sectors:
  - Residential load: Homes connected to the grid
  - Commercial load: General and hardware stores, hotels and restaurants
  - Municipal load: Banks, health centers, airports, post offices and government offices
  - Schools

<table>
<thead>
<tr>
<th>Residential load</th>
<th>660 kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial load</td>
<td>54.12 kWh</td>
</tr>
<tr>
<td>Municipal load</td>
<td>27 kWh</td>
</tr>
<tr>
<td>Schools</td>
<td>7.92 kWh</td>
</tr>
<tr>
<td>Total</td>
<td>749 kWh</td>
</tr>
</tbody>
</table>
As of June 2010, maximum load in Marsabit town was reported to be \(740\text{ kW}\)\(^*\).

The total load based on this estimation is \(749\text{ kW}\).


Peak Load at 7 pm (1900h)

Annual load growth of 250 connections. (17%)

Current technology mix:
- 1200 kW diesel capacity
- 650 kW wind capacity


Wind energy potential of Marsabit averaged over a 6 year period between 2001 and 2006.

Wind Power Analysis

- **Nordtank 150 kW XLR wind turbine**
  

  - Max power output of **144.1 kW**
  - Min Power output of **53.23 kW**
  - Power output at peak load: **113 kW**

Wind Power Analysis

- **Powerworks 250 kW WEG MS-2 wind turbine**
  

  - Max power output of **170.47 kW**
  - Min power output of **49.73 kW**
  - Power output at peak load: **115 kW**
Transmission line resistance: 
- 0.1576 Ω/km

Transmission line reactance: 
- 0.0968 Ω/km


Scenario 1:
- Diesel generator capacity from 2 of the 4 units, the 740-kW and the 435.3-kW generator (Total: 1,175.3 kW)
- Wind capacity of 650 kW, only 485 kW of this is actual wind power output
- Additional wind capacity of 500 kW added after 4 years to meet the growing demand
Results

Maximum wind energy at 1900 hrs

% Wind Input
% Diesel Input

Year

% Actual Wind Power Input to System at Peak hour:
Actual Wind gen/Max wind gen*100 = 70.87 %

% Predicted Wind Power Input to System at Peak hour:
Predicted Wind gen/Max wind gen *100

% Actual Wind Power Input to System:
Actual Wind input/Max wind output *100 = 70.87 %

% Predicted Wind Power Input to System:
Predicted Wind Input/Max wind output *100

Power Flow Simulation

Scenario 2:
- Diesel generator capacity from all 4 units. (Total: 1983.5 kW)
- Wind capacity of 650 kW, only 485 kW of this is actual wind power output
- No Additional wind capacity added

Scenario 3:
- Diesel generator capacity from 2 smaller units, the 435.3-kW and the 217.6-kW generator. (Total: 652.9 kW)
- Wind capacity of 650 kW, only 485 kW of this is actual wind power output
- Additional wind capacity of 1000 kW added after 4 years to meet the growing demand
Actual Wind Power Input to System:
Actual Wind input/Max wind output *100 = 70.87%

Predicted Wind Power Input to System:
Predicted Wind Input/Max wind output *100

Results

Conclusion

- Wind-diesel microgrid systems tends to be more reliable if the diesel generator capacity is increased as opposed to wind capacity during power system expansion to meet the growing demand.

Questions?