Lessons Learnt from a Storage Based Microgrid Application

Bunty Kiremire Pr.Eng
Senior Applications Engineer, Microgrid Energy Systems, Eaton
Agenda

• Brief introduction to Eaton
• Power Challenges in Africa
• Wadeville Case Study
• Business Case for Storage
• Role of Standards
Our **vision** is to improve the quality of life and the environment through the use of power management technologies and services.
Electrical Sector
2017 Sales $12.9 B
• Electrical Products
• Electrical Systems & Services

Industrial Sector
2017 Sales $7.5 B
• Aerospace
• Hydraulics
• Filtration
• Vehicle

Total sales $20.4 B
Net income $3.0 B

• Chairman & CEO – Craig Arnold
• Key locations: Cleveland, Shanghai, Morges (CH), São Paulo
• Regional engineering teams to support products and custom solutions
• Customers in more than 175 countries
• ~98,000 employees
Eaton’s solid presence in Africa

Dedicated diverse team
- 700 employees
- More than 100 distributors throughout Africa
- 5 offices across the continent
- 2 service hubs
- Engineering Services
  - Study | Design | Build | Support

Regional manufacturing capability
- 200k ft² of manufacturing space in South Africa and Morocco
- Africa based engineering services
- BBBEE Level 1 certification

A broad portfolio supplemented by “made for Africa” products and services
- IEC and UL approved products
- Historical brands in Africa since 1927
- Local manufacturing & engineering of Low Voltage, Medium Voltage and Power Quality products built for Africa

© 2019 Eaton. All rights reserved
A proudly BBBEE Level 1 contributor
A portfolio designed to meet your power management needs.
Power Challenges in Africa
## Low Access and Reliability

<table>
<thead>
<tr>
<th>Country</th>
<th>Electricity access %</th>
<th>Avg outage hours/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Côte d’Ivoire</td>
<td>61.9</td>
<td>230</td>
</tr>
<tr>
<td>DR Congo</td>
<td>13.5</td>
<td>850</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>27.2</td>
<td>570</td>
</tr>
<tr>
<td>Ghana</td>
<td>78.3</td>
<td>790</td>
</tr>
<tr>
<td>Kenya</td>
<td>36</td>
<td>420</td>
</tr>
<tr>
<td>Mozambique</td>
<td>21.9</td>
<td>80</td>
</tr>
<tr>
<td>Niger</td>
<td>15</td>
<td>1,400</td>
</tr>
<tr>
<td>Nigeria</td>
<td>56.4</td>
<td>4,600</td>
</tr>
<tr>
<td>Senegal</td>
<td>61</td>
<td>130</td>
</tr>
<tr>
<td>South Africa</td>
<td>86</td>
<td>50</td>
</tr>
<tr>
<td>Tanzania</td>
<td>18.9</td>
<td>670</td>
</tr>
<tr>
<td>Zambia</td>
<td>27.9</td>
<td>180</td>
</tr>
</tbody>
</table>

Global Energy Access
Rising Costs of Electricity

Trend in Average Electricity Prices realised by Eskom per kWh (1973 to 2015/16)

Source: Deloitte Analysis, Eskom data and 2011 annual report
Note: In 2004/5 Eskom change financial year from calendar year (year-ending 31 December) to year-ending 31 March
Evolving Power Sector Landscape:

Historical Typical Power Grid

- One Way Power Flow
- Generation: Few Base load Sources
- Transmission
- Distribution: Substations
- Customers

Decentralized Grid

- Power Flows in Many Directions
- Fossil Fuel - generator
- Solar PV - generator
- Wind - generator
- Battery - storage
- Power Xpert Energy Optimizer controller
- Facility - load
- Utility - source

© 2019 Eaton. All rights reserved
A proudly BBBEE Level 1 contributor
What is a Microgrid?

Microgrids are stand-alone power generation, distribution and storage systems that work with or independently from the main utility grid to help businesses, campuses and communities to:

- Maintain reliable supply of power
- Reduce operating costs
- Optimize energy usage
- Reduce carbon emissions
Key Challenges at Eaton’s Wadeville facility:

Due to ageing infrastructure we experienced increased in load shedding due to:

- Cable faults
- Scheduled maintenance of the grid

As a manufacturing facility we faced:

- Increase energy charges impacted by seasonality and peak time
- Network demand charges
Business Case for Wadeville Plant

Three main use cases enabled by storage:

- **Peak Shaving**
  - Reduce demand / peak charges
  - Maintain constant demand day or night

- **Integrated PV**
  - Reduced PV variation with energy storage system
  - Reduce utility demand

- **Islanding**
  - Continuous operation of manufacturing regardless of utility supply
  - Minimize backup fuel consumption

Reduced Energy Charges
Improved overall power quality
Mission critical operation uninterrupted
Key Hardware Components of the Wadeville Microgrid

- **Sources**
  - Utility
  - 400 kVA Generator
  - 200 kW Photovoltaic
  - 275 kW Battery Storage (200 kWh)

- **Loads**
  - 50 – 375 kVA (30 min readings)
  - 70 kW compressor

- **Use Cases (partial list)**
  - Peak Power Limiting / Load Leveling
  - Renewable Firming
  - Load Shifting
  - Resiliency: Islanded operation optimizing renewables

- **Power Distribution Centre**
  - CX 630 A, 32 kA

- **Battery Storage**
  - 200 kWh Nissan Second Life

- **Photovoltaic**
  - 232 kWp

- **Diesel Generator**
  - 400 kVA

- **6.6 kV Utility**
  - XIRIA E

- **6.6 kV/400 V**
  - 2 x 500 kVA

- **275 kVA**
  - XST PCS 275 LARGE

- **4 x 50 kW Inverters**
Business Case for Storage
Value Stream 1: Energy Arbitrage
Reduce Grid Consumption when Costs are Highest

<table>
<thead>
<tr>
<th></th>
<th>Summer Morning Peak</th>
<th>Summer Evening Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Summer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R0.76 ($0.05)</td>
<td>R1.54 ($0.11)</td>
<td>R1.01 ($0.07)</td>
</tr>
<tr>
<td>R1.54 ($0.11)</td>
<td>R5.39 ($0.40)</td>
<td>R1.54 ($0.11)</td>
</tr>
<tr>
<td><strong>Winter</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R0.91 ($0.06)</td>
<td>R5.39 ($0.40)</td>
<td>R1.54 ($0.10)</td>
</tr>
<tr>
<td>R1.54 ($0.10)</td>
<td>R5.39 ($0.40)</td>
<td></td>
</tr>
</tbody>
</table>

- Peak
- Off Peak
- Standard
Value Stream 1: Energy Arbitrage
Reduce Grid Consumption when Costs are Highest

Off Peak Tariff  Peak Tariff  Standard Tariff

Charge at R0.91
($0.06) rate

Discharge during Peak Period R5.39 ($0.40)
for net benefit of R4.48 ($0.34) per kWh
Value Stream 2: Offset Energy Costs
Solar PV and Storage Reduce Total Grid Consumption
Value Stream 3: Renewable Maximization
Storing Excess Solar
Value Stream 4: Outage Avoidance
Eliminate Production Losses Due to Power Outages
Role of Standards
Microgrid Standards & Guidelines

Standards play a key role in the design, installation, and operation of Microgrids and Embedded Generation Systems

- IEEE 2030.7; 2030.8
- IEEE 1547.3; 1547.4
- SANS 10142
- NRS 097
Implications of Limited Standards in Storage

• Difficulty for customers to align needs with suitable battery technology for application
• Challenges with regulation and compliance
• Push for commoditization of energy storage systems based on price not function
Conclusion: We Need Standards

• Ensure consistency
  • Quality assurance
  • Safety
• Increase consumer and utility confidence
• Assess different energy storage offerings against a common benchmark