Advanced Lead-Acid Batteries with Smart Carbon Technology – Africa Case Studies
Topics

- Power in Africa
- State of the Art Manufacturing Process for High-quality Deep-cycle Batteries
- Introducing Smart Carbon™
- Compliance with Standards for Solar Batteries. IEC Test 61427
- Trojan batteries in the Field
Power in Sub-Saharan Africa

- Sub-Saharan Africa has total installed capacity of Spain
- South Africa produces 2/3 of the continent's power
- 90% of power supplied by coal-fired power stations
- Exporting only about 5% to other SADC countries
- Load shedding program implemented since rolling black-outs started in 2007
- 29% average of installed capacity unavailable
- 2084 MW currently produced by OCGT’s for 16 hours p/d
- Production at 4.8 times cost of other power stations
# Power in Africa

<table>
<thead>
<tr>
<th></th>
<th><strong>ELECTRICAL GRID</strong></th>
<th><strong>DIESEL GENERATOR</strong></th>
<th><strong>SOLAR ENERGY</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technical reliability</strong></td>
<td>Low</td>
<td>Medium</td>
<td>Excellent</td>
</tr>
<tr>
<td></td>
<td>Blackouts, brownouts, outages, breakdowns, voltage drops, etc..</td>
<td>Breakdown may be frequent due to mechanical parts.</td>
<td>Breakdown very rare. Grid outages avoided.</td>
</tr>
<tr>
<td><strong>Energy independence</strong></td>
<td>Low</td>
<td>Low</td>
<td><strong>Good to excellent</strong></td>
</tr>
<tr>
<td></td>
<td>Centralised system</td>
<td>Problems with fuel supply (shortages, transport costs, etc.)</td>
<td>None (100% solar) to very low (hybrid) fuel dependency</td>
</tr>
<tr>
<td><strong>Social and economic benefits</strong></td>
<td>Low</td>
<td>Low</td>
<td>Excellent</td>
</tr>
<tr>
<td></td>
<td>Benefits go to large electricity producers and distributors corporates</td>
<td>Fuel purchases cause a negative balance of trade</td>
<td>Decisions and socio-economic benefits are local (education, jobs created, health, etc.)</td>
</tr>
<tr>
<td><strong>Impacts on health &amp; environment</strong></td>
<td><strong>Moderate to high</strong></td>
<td>High</td>
<td>Low to none</td>
</tr>
<tr>
<td></td>
<td>Greenhouse gases emissions by thermal power plants (coal, gas, fuel).</td>
<td>Important greenhouse gases emissions and noise pollution</td>
<td>Green house gases emissions and noise pollution are low (hybrid) to inexistent (100% solar)</td>
</tr>
<tr>
<td><strong>Operation costs</strong></td>
<td><strong>Moderate to high</strong></td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Ageing power infrastructures are often expensive and unreliable.</td>
<td>Expensive fuel and maintenance costs.</td>
<td>Once the upfront investment done operation and maintenance costs are very low.</td>
</tr>
<tr>
<td><strong>Economic competitiveness</strong></td>
<td>Varies with countries</td>
<td>Low</td>
<td><strong>Good to excellent</strong></td>
</tr>
<tr>
<td></td>
<td>Electricity wholesale prices vary from country to country due to governmental subventions, power generation facilities and natural resources.</td>
<td>Generator life cycle cost is very high due to short life time paired with expensive operation and maintenance costs.</td>
<td>Off-grid solar energy is 2 to 3 times cheaper than diesel generator. For large scale grid-connected plants, analysis must be done case-by-case.</td>
</tr>
<tr>
<td><strong>Energy cost volatility</strong></td>
<td>High</td>
<td>Very high</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>In Africa, grid electricity prices are likely to increase in order to replace old infrastructures and increase generation capacity.</td>
<td>Oil resources scarcity and demand increase will cause substantial market prices increase.</td>
<td>Energy from the sun is free. Module performances are guaranteed over 25 years and the real lifetime is about 30 to 40 years.</td>
</tr>
</tbody>
</table>
Quality Knows no Boundaries

- Legacy of building high quality “Made in the USA” batteries since 1925
- Exclusive focus on manufacture of deep cycle batteries; Flooded and VRLA
- A brand new state of the art production facility in the USA dedicated to VRLA batteries
- Distribution in over 100 countries worldwide, with 100+ domestic warehouses in the US
- A team of dedicated Telecom & Renewable Energy experts combined with battery expertise
- Third party lab testing showing that Trojan consistently outperforms the competition
- State of the art lean, ISO certified manufacturing facilities
Headquartered in California with 4 USA manufacturing facilities in the USA & global distribution & offices

Sales presence in 120+ countries globally
Presence in Africa - updated

Successful with 5 Product Families

© 2015 Trojan Battery Company
Renewable Energy & Backup Power Applications
State of the art facilities, automation and equipment

**Frost & Sullivan 2013 “Innovative Enterprise” Award**

*Trojan Battery Receives Frost & Sullivan 2013 “Innovative Enterprise” Award*

Trojan Battery Company, the world’s leading manufacturer of deep-cycle batteries, has been honored by industry research and consulting firm Frost & Sullivan and awarded its 2013 Manufacturing Leadership 100 Award (ML100) in the category of “Innovative Enterprise.”

Trojan Battery was recognized for its innovative use of technology and equipment at its Lithonia, Ga. manufacturing facility. Since the manufacture of deep-cycle batteries takes precision, accuracy and succinct methods to ensure the proper assembly of the delicate internal components, Trojan implemented specially designed Cast-On-Strap (COS) equipment to ensure the proper placement and connectivity of deep-cycle battery features, which ensures the highest level of product quality.

“Trojan Battery is honored to receive this prestigious recognition by Frost & Sullivan for the company’s advanced manufacturing processes,” said Gordon Beckley, senior vice president of engineering and quality assurance for Trojan Battery. “This award reinforces Trojan’s strategy of combining advanced manufacturing technology, premium components, and exacting standards for quality to ensure our batteries provide customers with the performance and reliability Trojan has become known for over the past 85 years.”
Expertise in the entire battery manufacturing process, made in the USA with strict quality controls

Grid manufacturing / pasting
Plate curing chambers
Cell balancing and assembly
Battery formation
Finishing, cleaning and final QA

Approximately 570 hours to produce a high quality, deep cycle battery
World leader in deep-cycle battery technology / R&D

Trojan has two of the largest and most extensive bi-coastal research & development centers dedicated to battery technology in North America.

Intimate knowledge of charging technology and algorithms provides unique performance advantages for our OEM customers.

Development teams backed by 30 years of proprietary process knowledge and combined deep cycle development experience of 120 years.

On-going efforts encompass extending next generation technology to all battery product lines, continued value engineering and new product categories.
Renewable Energy Product Range

Trojan Battery offers a broad portfolio of batteries, including Deep-cycle flooded, AGM and Gel VRLA batteries in monoblock and industrial sizes.
Introducing Smart Carbon™

Trojan recently launched a new technology in its Industrial and Monoblock flooded battery product lines designed for Telecom & Renewable Energy applications which are cycled in a Partial State of Charge (PSOC).

**Description of the Problem**

- Lead-acid batteries need full recharge after each discharge for optimal cycling performance.
- Some cycling applications only partially recharge batteries, resulting in what is called partial state of charge (PSOC) cycling.
- PSOC cycling is a particular problem in renewable energy applications.
- PSOC cycling is harmful to the battery and leads to significant reductions in cycle life.

**Our Solution**

- We focused on the failure mode of the batteries which was sulfation on the negative plate.
- Several years of R&D work took place to determine the best solution to keep Trojan batteries healthy when operating in PSOC applications.
- And Smart Carbon (SC) was created....
Why Smart Carbon™ Is A Solution To The Problem

- Higher conductivity
- Reduced sulfation
- Improved opportunity charging

Superior PSOC performance
Proving That The Smart Carbon Solution Works

The Benefits of Smart Carbon™ in PSOC Applications

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Cycle Life at 50% DOD</th>
</tr>
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<tbody>
<tr>
<td>Battery Operating at a Full State of Charge</td>
<td>2,800</td>
</tr>
<tr>
<td>Battery Operating in a Partial State of Charge Application (PSOC) without Smart Carbon</td>
<td>2,240</td>
</tr>
<tr>
<td>Battery Operating in a Partial State of Charge Application (PSOC) with Smart Carbon</td>
<td>2,576</td>
</tr>
</tbody>
</table>

SMART CARBON CYCLE LIFE in Partial State of Charge (PSOC) Applications

More cycle life when used in PSOC applications UP TO 15%

Capacity

Cycles

Smart Carbon  Non-Carbon

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Trojan Industrial Line – 17 years service life per the IEC 61427 test

The Industrial battery reached its end of life after the 17th macro cycle, or after a total of 2,550 micro cycles. Because of the two factors mentioned in the previous paragraph (PSOC cycling and cycling at a continuous temperature of 40°C ± 3°C), each macro cycle that the battery successfully delivers is considered to be the equivalent of one year of service life for the battery.

Therefore, since the Industrial battery delivered 17 macro cycles before its delivered capacity dropped to under 80% of its rated capacity, we can say that Trojan Battery Company’s Industrial battery line has a service life of 17 years, which is reflected in Table 3 below.

Finally, the results obtained from testing the IND13-6V model apply fully to all other Industrial models (current and future) by virtue of similarity of design.

<table>
<thead>
<tr>
<th>Battery type</th>
<th>Equivalent service life</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Industrial models</td>
<td>17 years</td>
</tr>
</tbody>
</table>

Note – this test was complete on the Industrial line batteries prior to the Smart Carbon additive. The Smart Carbon version is on test now.
Off-grid Solar Commercial

Center for Alternative Technology, Kenya Nature Reserve
(24) Trojan IND17-6V
Off-grid Solar Commercial

Omnisolar, South Africa
Commissioned - 2015
Off-grid lodge
(48) Trojan IND33-2V
Off-grid Solar Commercial

Kenya
Off-grid electrification
Commissioned - 2014
(24) Trojan IND17-6V
Off-grid Solar Commercial

Riwik - East Africa
Power Back-up systems
Commissioned - 2015
J185-HAC
Inverter Back-up

Eauxwell Nigeria Limited, Nigeria
Solar Powered Bank ATM Inverter Backup
Commissioned - 2014
(16) Trojan L16RE-B
NewLord, Nigeria
Inverter Backup – Intercontinental, Lagos
Commissioned - 2015
(120) Trojan J185P-AC
- Thank you

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