Vanadium Redox Flow Batteries – Ideal for Microgrid Applications

NY-BEST
March 9, 2017
Albany, NY
Matthew Maiers, Business Development, Americas

www.energy.gildemeister.com
CellCube: Proven Track Record Flow Battery

The CellCube History

- Research and development
- CE certification
- Market launch FB 200 modules
- More than 100 projects installed worldwide
- Market launch New Gen FB250
- First field tests
- 1999
- 2004
- 2008
- 2012
- 2014
- 2017

Over 130 installations since 2008

Employees | Facility Grounds | Manufacturing
--- | --- | ---
65 | 14,888 m² | 3,010 m²
160,253 sq. ft. | 32,290 sq. ft.

Certified by:

13-Mar-17

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CellCube Global Installations

World Overview

NAFTA
730 kW
2,990 kWh

Europe
3,130 kW
13,240 kWh

Middle East, Africa
150 kW
1,280 kWh

RoW
30 kW
200 kWh

Asia
250 kW
1,930 kWh

Sold
Power: 4.3 MW
Energy: 19.6 MWh

World Overview
HQ & Sales Rep
Sales Partner
Service Partner
installed
One Battery – Many Applications

Fast Response AND Long Duration: Maximize Revenue

Ancillary Services, Power Quality

Renewables Shift

Peaking Plant Alternative

Distributed Gen, RE Capture, Microgrid

20ms 15min 1h 2h 4h 8h 12h
Frequency Regulation
Utility Energy Supplier / Germany

- Frequency Regulation Market
- Intraday Energy Trading Markets
- Grid Stabilization - Voltage and Frequency Support

<table>
<thead>
<tr>
<th>Location</th>
<th>Tussenhausen, Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated power</td>
<td>200 kW</td>
</tr>
<tr>
<td>Rated capacity</td>
<td>400 kWh</td>
</tr>
<tr>
<td>Product</td>
<td>1x CELLCUBE FB 200-400</td>
</tr>
<tr>
<td>Installation date</td>
<td>2nd Quarter 2015</td>
</tr>
<tr>
<td>Throughput (MWh Discharged)</td>
<td>10.3 MWh As of 1st Quarter 2016</td>
</tr>
<tr>
<td>Application</td>
<td>Frequency Regulation</td>
</tr>
<tr>
<td>Market sector</td>
<td>Utility</td>
</tr>
</tbody>
</table>

Photo © Sebastian Aschenbrenner / LEW Verteilnetz GmbH

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**Grid Services**

Transmission System Operator (TSO) / Italy

<table>
<thead>
<tr>
<th>Location</th>
<th>Codrongianos, Italy</th>
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</thead>
<tbody>
<tr>
<td>Rated power</td>
<td>400 kW</td>
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<tr>
<td>Rated capacity</td>
<td>1200 kWh</td>
</tr>
<tr>
<td>Product</td>
<td>2x CellCube FB 200-600</td>
</tr>
<tr>
<td>Installation date</td>
<td>3rd Quarter 2016</td>
</tr>
<tr>
<td>Application</td>
<td>Grid related services, frequency and voltage support</td>
</tr>
<tr>
<td>Market sector</td>
<td>Grid Services</td>
</tr>
</tbody>
</table>
Capacity / Grid Services
2MW / 8MWh: IESO / Canada

- Fixed Contract – Capacity Availability
- Grid Services

- Project Developer and Owner: Baseload Power Corp.
- 10 year IESO contract – pays fixed monthly amount based on availability and monthly cycling requirements.

- Contract allows for the project to participate in other IESO markets and earn additional revenue above the contracted availability payments.

<table>
<thead>
<tr>
<th>Location</th>
<th>Ontario, Canada</th>
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<tbody>
<tr>
<td>Rated power</td>
<td>2 MW</td>
</tr>
<tr>
<td>Rated capacity</td>
<td>8 MWh</td>
</tr>
<tr>
<td>Product</td>
<td>8 CELLCUBE FB 250-1000</td>
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<td>Installation date</td>
<td>Q2 2017</td>
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<tr>
<td>Throughput</td>
<td>N/A</td>
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<tr>
<td>Application</td>
<td>Capacity, grid services</td>
</tr>
<tr>
<td>Market sector</td>
<td>Utility</td>
</tr>
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</table>
Utility Scale Microgrid - Renewables Integration
Utility Energy Supplier / Germany

- Utility Scale Microgrid in a UNESCO World Protected Area
- Increase RE Fraction of PV (2 MW) & Wind (7 MW)

<table>
<thead>
<tr>
<th>Location</th>
<th>Pellworm, Germany</th>
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<tbody>
<tr>
<td>Rated power</td>
<td>200 kW</td>
</tr>
<tr>
<td>Rated capacity</td>
<td>1600 kWh</td>
</tr>
<tr>
<td>Product</td>
<td>1x CELLCUBE FB 200-1600</td>
</tr>
<tr>
<td>Installation date</td>
<td>3rd Quarter 2013</td>
</tr>
<tr>
<td>Throughput (MWh Discharged)</td>
<td>142 MWh As of 1st Quarter 2016</td>
</tr>
</tbody>
</table>
| Application       | • Self consumption optimizer on the island  
                          • Base load supply for 150 out of 600 households |
| Market sector     | Utility           |

Photo © Dieter Haack / Schleswig-Holstein Netz AG
Island System – Microgrid: (UAE)

100% DIESEL substitution, microgrid for office-building and workers camp

- **Primary Mission**
  - 100% renewable for office building and workers camp 24/7
  - 100% substitute DIESEL
  - Backup for office-building

**System Configuration**

- **SC-220 33kWp**
- **fixed 18.5kWp**
- **FB 10-100**
  - 10kW, 15kWp
  - 100kWh
- IT, HVAC, Lighting in Office-building Workers camp
- No grid
Island System – Microgrid: (Bhopal, IND)

Predictable generation of renewable energies, uninterruptible power supply for regions with weak grid

- 100% renewable for office building 24/7
- Day-time Shifting
- Backup for office-building

Primary Mission

Office-building

SC-260 48kWp

3x FB 10-100
30kW, 45kWp
## Off-Grid System

**Off-Grid System / Vietnam**

- Power existing buildings and nearby construction site
- Integrate PV (20 kW), Wind (10 kW), & diesel genset (10 kW)
- Maintain grid voltage and frequency

<table>
<thead>
<tr>
<th><strong>Location</strong></th>
<th>Con Dao Island, Vietnam</th>
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<tbody>
<tr>
<td><strong>Rated power</strong></td>
<td>10 kW</td>
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<tr>
<td><strong>Rated capacity</strong></td>
<td>40 kWh</td>
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<tr>
<td><strong>Product</strong></td>
<td>1x CELLCUBE FB 10-40</td>
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<tr>
<td><strong>Installation date</strong></td>
<td>3rd Quarter 2015</td>
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<tr>
<td><strong>Throughput (MWh Discharged)</strong></td>
<td>5.8 MWh As of 1st Quarter 2016</td>
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<td><strong>Application</strong></td>
<td>Off-grid stand-alone system</td>
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<td><strong>Market sector</strong></td>
<td>Utility, off-grid</td>
</tr>
</tbody>
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**Application Diagram**

- CELLCUBE®
- Loads
- PV
- Wind
- Genset

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13-Mar-17

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DC Microgrid
Burlington, Ontario Canada

- Rooftop solar panels, natural gas DC generator, and 5-hour duration CellCube flow battery.
- Interconnected to the utility grid for energy import/export and ancillary services, and seamlessly operates during grid disturbances and outages.
Microgrid System
Rural Electrification / Kitobo Island in Lake Victoria, Uganda

- Power 600 Households i.e. 2,000 citizens on Kitobo Island
- Integrate PV (235 kWp) & back-up diesel genset
- Creates business on the island - within 2 months installation of 2 electronic-supply shops & installation of groundnut mill

<table>
<thead>
<tr>
<th>Location</th>
<th>Kitobo Island, Lake Victoria, Uganda</th>
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<tbody>
<tr>
<td>Rated power</td>
<td>60 kW</td>
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<tr>
<td>Rated capacity</td>
<td>520 kWh</td>
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<tr>
<td>Product</td>
<td>4x CELLCUBE FB 15-130</td>
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<tr>
<td>Installation date</td>
<td>4th Quarter 2016</td>
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<tr>
<td>Throughput</td>
<td>1.0 MWh As of 1st Quarter 2017</td>
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<tr>
<td>Application</td>
<td>Renewable energy supply of a village on an island in Lake Victoria</td>
</tr>
<tr>
<td>Market sector</td>
<td>Island Grid</td>
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</tbody>
</table>

PV

CELLCUBE®

Genset

Loads
Uganda – Rural Electrification

Logistics

1. AT – IT Truck
2. IT – Kenia - Boat
3. Kenia – Uganda Truck
4. Lake Victoria – Boat
5. On Island – Truck/Crane
Uganda – Rural Electrification
Logistics
Uganda – Rural Electrification

Installation
CellCube provides high value & high performance in Microgrid projects

- No cycle life limitations
- 20 year life – no refresh required
- Very long discharge duration capabilities
Thank You!

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