Breeze Production
Wind Farm Management System

Software for wind farm owners and operators.
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Greenbyte, the company behind Breeze, was founded in 2010 based on the firm belief that the inherent variability in the “fuels”, for renewable electricity production make the industry highly dependent on quality data to create value.

During the company’s four year life time this belief has proven to be true and to become increasingly important. Value creation in the renewable energy industry is dependent on high quality data from production assets.

With so many actors in the value chain dependent on data to create value there is a need for products leveraging modern software to make the data available. During the past four years Greenbyte has developed two products – Breeze Development – for wind energy project developers and Breeze Production – for wind turbine owners.

Breeze is used globally by customers in the Nordics, Belgium, France, Netherlands, Israel, South Africa, Australia, Uruguay and Costa Rica.
Studies show that there is untapped potential in most wind farms. How does Breeze achieve improvements in wind farm operations?

- Increase uptime and leverage asset production more effectively
- Realize substantial time-savings from portfolio-wide software system
- Take targeted actions based on observed trends or degradation of performance
- Track whether corrective actions have improved output and quantify the results
- Provide hard data to assist owners and operators during negotiations with wind turbine manufacturers
- Create better and more accurate performance-based contracts for hired service providers
- Deliver additional value when potential buyers are considering purchasing assets

“Breeze helps us maximize returns from investments.”

Jonas Larsson, Project Manager at Jämtvind
Customers
Wallenstam builds, develops and manages properties for sustainable living and enterprises in expansive regions in Sweden. Wallenstam’s reported property value is approx. EUR 3.25 billion.

In addition to being one of the top 10 property owners in Sweden Wallenstam has invested in wind power to provide 100% clean energy to all of its customers. Wallenstam currently owns 141 MW of wind power. The portfolio consists of multiple types of turbines such as Vestas V90, Enercon E82, Siemens 2.3.

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Owner and Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>141 MW</td>
</tr>
<tr>
<td>Wind Turbines</td>
<td>70</td>
</tr>
</tbody>
</table>

“An easy to use platform that requires very little training.”

Kaj Lampton, VP Wallenstam Wind Power
As one of the largest Dutch private investment firms in the area of onshore wind farms YARD ENERGY develops, finances and manages wind farms in the Netherlands, Belgium, Finland and Poland.

YARD ENERGY Group has taken a revolutionary approach to its infrastructure, allowing them to manage a large portfolio with a small team of professionals using cost effective management processes. Breeze is now an integral part in delivering data for business intelligence and reporting by centralizing production figures, forecasts, budgets, availability metrics and power prices.

“Breeze fits right into our IT strategy of leveraging the latest web-based solutions for efficient and cost effective asset management that is fully scalable-upon-demand where you pay as you grow.”

Teele Horstra, Chief Operating Officer

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Owner and Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>107 MW</td>
</tr>
<tr>
<td>Wind Turbines</td>
<td>46</td>
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Rabbalshede Kraft is one of the most ambitious pure wind power independent power producers in the Nordics. Founded in 2005 Rabbalshede Kraft now use Breeze for wind farm management.

The Company has another 33 turbines under construction and about 300 wind turbines in the procurement, application or planning phases. Production and sale of renewable electricity, construction of new wind farms, along with an extensive portfolio of projects comprises the basis for growth.

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Owner and Operator</th>
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<tbody>
<tr>
<td>Capacity</td>
<td>193 MW</td>
</tr>
<tr>
<td>Wind Turbines</td>
<td>73</td>
</tr>
</tbody>
</table>

“We choose to work with Breeze due of the level of insight provided by Breeze and the Breeze team’s agile product development approach.”

Lars Jacobsson, Operations Manager
VindIn is owned by ten of the largest industrial players in Sweden including Akzo Nobel, Boliden, AGA, Preem, Stora Enso, Holmen.

The rationale for investing in wind power and operating wind farms is to keep electricity prices low in the nordics.

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Owner and Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>78 MW</td>
</tr>
<tr>
<td>Wind Turbines</td>
<td>35</td>
</tr>
</tbody>
</table>
Product Overview
Breeze User Types

Operators

Operators use Breeze to quickly be notified of downtime or any under performance and to keep track of all logs and documentation related to wind farm management.

Analysts

Analysts use Breeze as a first instance to find underperforming turbines in order to suggest actions for increased wind energy production.

Managers

Managers use Breeze to evaluate ROI on investments that affect performance and to follow key metrics such as actual production, availability, wind against budget.
- Secure cloud-based infrastructure hosted by Amazon Web Services
- Scalable from a single turbine to GW sized portfolios
- Long term storage of 10min historical data for future analysis
- API for sharing data with other programs and service providers
- User friendly dashboards and graphics
- Automatic notifications via email and automatic monthly report generator
- App for iOS and Android devices to view status and alarms
- Used in wind farms across Europe and compatible with any turbine
- Actionable information for constructive discussions with wind turbine manufacturers
- Learned power curve
Monitor production levels and alarms from your wind turbines in real time.

Analyze and compare operational and financial data across the portfolio.

Track and evaluate ROI in performance enhancing investments over time.

Centralize and secure all wind farm data for long term storage.

Use Breeze on your smartphone and leverage the powerful API.
MONITOR

Operator’s Dashboard - Map Overview - Monitor Wind Farm
Monitor Wind Turbine - Alarms and Error Categorization
Operator’s Dashboard

- Real time portfolio overview
- Portfolio availability / production past 24 h
- Error intensity
- Scheduled maintenance information
- Lost production in real time
- Lost Production Factor in real time
Map Overview

- Portfolio overview
- Detailed wind farm info
- Terrain, Satellite, Road view
Wind Turbine

- Detailed real time turbine data
- Nacelle mis-alignment in real time
- Easy access to wind, power and potential power last 24h
Alarms & Notifications

- Status codes and summary sent by email
- Customize notifications
- Early warning based on custom filters unrelated to turbine manufacturer warning system
- All errors and warnings stored in log
- Filter based on wind farm, turbine, error code, comment
- Comment on errors
Error Categorization

- Categorize errors for overview and informed O&M decisions
- Easy default categorization
- Manual over ride with full traceability
- Categorization tightly linked with contractual availability
ANALYZE

Performance - Stop - Loss - Weather - Custom Data
Performance

- Identify under performing turbines
- Compare potential power with actual power
- Power curve comparison between turbines and time periods
- Learned power curve stored on a monthly basis for later comparison
- Analyze power curve with advanced filter settings
Stop

- Identify most problematic stops across portfolio
- Categorize stops
Loss

- Identify stops that account for most Lost Production
- Base O&M decisions on lost production
- Calculate lost production using Reference turbine, warranted power curve, learned power curve
Weather

- Measure and analyze meteorological conditions
- Functionality with third-party weather and forecast programs
Custom Data

Integrate custom data sets such as:

- Electricity prices
- Production forecasts
- Meter data from grid operator
- Video surveillance
- Substation
Budget & KPI's - Scheduled Maintenance
Contractual Availability - User Permissions - Reports
Budget & KPI’s

- Observe trends
- Budget vs Actuals
- Drill down
- Define time period
- Portfolio and wind farm level
- Customize dashboard
- Portfolio efficiency - lost production factor
Scheduled Maintenance

- Schedule maintenance and compare with actual maintenance
- Full control of when ISPs and OEMs perform maintenance
Contractual Availability

- Define availability calculations based in wind farm specific contracts
Flexible User Permissions

- Specify user permissions based on wind farm and turbine
- Define level of access to Breeze and data
Reports

- Use built in configurable reports
- Customize reports to fit organisation’s reporting format
- Automatically generated and distributed
Network Architecture - Wind Farm Architecture
Data Security - Data Collection
Wind Farm Architecture

Customer Equipment

Wind Turbine
- Wind Turbine HMI & Controller
- Wind Turbine Network Fiber Optic Switch

Wind Farm 100 Mb Fiber Optic LAN

Substation / O&M Building

Customer Remote LAN Connection / Modem

Customer Applications
- Customer Applications
- OPC Server Software
- Modbus Client Interface
- SCADA Software
- ODBC Interface
- Historical Database
- GPS Time Server
- Tape Backup System

Breeze Real Time System OPC/XML & Historical Database Collector (ODBC)

Customer Remote Viewer PC

Customer Applications

Substation / O&M Building

IPSEC VPN Connection

Customer Connection

GE Connection (B2B/VPN)

GE Remote Monitoring & Diagnostics Center

ODBC Interface

Historical Database

GPS Time Server

Tape Backup System

Wind Turbine Network Fiber Optic LAN

Wind Turbine

GE Connection (Modem or VPN)
Breeze utilizes the Amazon Web Services, state-of-the-art datacenters, utilizing industry-leading architectural and engineering approaches.

Client data is stored in a private encrypted database. The private database is in turn stored within a private virtual cloud within the Amazon infrastructure which ensures that only permitted network traffic can reach the database. There is no way to directly access the private database.

Amazon’s data centers are housed in nondescript facilities. Physical access is strictly controlled both at the perimeter and at building ingress points by professional security staff utilizing video surveillance, intrusion detection systems, and other electronic means. Authorized staff must pass two-factor authentication a minimum of two times to access data center floors.

10-minute averaged data is pushed to a special area within the Amazon infrastructure which is designed to provide 99.999999999% durability over a given year. The entire private client database, including the long time storage, is backed up daily to further minimize the risk of data loss.
Breeze clients get their own private encrypted database in Breeze where data is stored immediately, without any intermediary storage.

Data is stored in a way that ensures both physical and local integrity. Breeze normally collects real-time data from wind turbines in the range of 0.025 to 1 Hz (every 1 to 40th sec).

Besides collecting real-time data, Breeze aggregates data points for 10-minute average values for long-term storage. A data collection rate of 1 Hz means 600 data points per signal is collected every 10 minutes.
Breeze API - Park PC Data Buffer - Wind Farm Monitoring For Your Mobile Device
The Breeze Production Application Programming Interface (API) can be used to integrate Breeze with third-party services.

The API allows users and third-party services to read data directly from Breeze Production in real-time, such as:

- **Turbine list** - List all available turbines.
- **Turbine status** - Display the current status for all turbines (OK / Warning / Stop etc).
- **Scheduled maintenance** - Display scheduled maintenance (if any) for all available turbines.
- **Real-time data** - Display the most recent data for all available turbines.
- **Average data, all turbines** - Display the data for a 10-minute, 1-hour, 1-day, 1-month or 1-year period for all available turbines.
- **Average data, single turbine** - Display the data for a 10-minute, 1-hour, 1-day, 1-month or 1-year period for a single turbine.
The ParkPC is an industrial PC that is installed in the wind farm. It interfaces with the wind farm with any of the standard data communication channels as described earlier in this document or directly with the control system.

A ParkPC is installed when there is either no standard method for real-time data communication in the wind farm or when no access to a historical database in the wind farm and the internet connection is unreliable.

ParkPC acts as a data buffer. When a ParkPC is installed in a wind farm Breeze collects data from the ParkPC. In the event that internet communication becomes unavailable real time data is buffered on the ParkPC. When internet communication becomes available again all data is sent to Breeze.

**Physical**

- 29 x 34 x 13 cm, 3.5 kg, mounted with screws, -20°C to 40°C operational and storage

**Power Supply**

- 230 VAC, self-charging 12 VDC/1.3 Ah battery, logging memory, SSD 64GB

**Communication Options**

- Fiber, GPRS 3G LTE, ADSL, mobile broadband, satellite
The Breeze Wind Farm Monitoring app for iOS and Android lets you monitor key metrics for your entire portfolio of wind turbines on the go. The app collects data from wind farms and presents it in a user-friendly interface on your mobile device. Access live wind power production data for your entire portfolio or drill down to see the status of each wind turbine on the go.

Monitor conditions such as:

- Total energy production
- Turbine status
- Yearly energy production
- Turbine maintenance
- Wind direction
- Energy production per turbine
- Wind speed
- Temperature
Installation & Support
New wind farms and turbines can be added to Breeze at any time. In general, the installation process for a new wind farm looks like this:

1. Establish and configure the data communication between Breeze and the SCADA-server in the wind farm, possibly including the configuration of an optional IPSEC or OpenVPN tunnel.

2. Configure the Breeze backend to properly interpret data from the wind farm.

3. Configure the Breeze frontend to properly display data from the wind farm.

In order to establish the data communication between Breeze and your wind farm, you must know which communication interfaces that are available in your wind farm. The turbine manufacturer should be able to answer any such questions. Once the data communication is established, the backend and frontend configuration can be completed. The configuration is performed by the Breeze team.
The Breeze team supports users around the world from our headquarters in Gothenburg Sweden.

Friendly and knowledgeable professionals provide support by phone, email or submitting a question directly through the Breeze program.

Rather than viewing support as a burden, we view support discussions as an ideal way to collaborate further and to take good ideas and build them into Breeze. Many features were in fact suggested by users of Breeze.

Contact Us

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“Excellent customer service and even better software!”

Aaron Donoghue, Impax Asset Management, UK

Meet our friendly support team!

Mats Johansson
Oscar Winter
Anders Homström
Breeze Production is developed and released in a Continuous Delivery (CD) fashion. Continuous Delivery (CD) is a design practice used in software development to automate and improve the process of software development. Unlike conventional software, no updates need to be installed by the user and there is no version history to keep track of.

Techniques such as automated testing, continuous integration and continuous deployment allow software to be developed to a high standard and easily packaged and deployed to test environments, resulting in the ability to rapidly, reliably and repeatedly push out enhancements and bug fixes to customers at low risk and with minimal manual overhead.

We adhere to the Release Early, Release Often (RERO) software development philosophy. RERO emphasizes the importance of early and frequent releases in creating a tight feedback loop between developers and testers or users, contrary to a feature-based release strategy. This allows software development to progress faster, enables the user to help define what the software will become, better conforms to the users’ requirements for the software, and ultimately results in higher quality software.

“Breeze is the most modern software for wind farm management out there. Of all products evaluated, no other system was built from the ground up using a true cloud-based Software-as-a-Service approach.”

Teele Horstra, YARD ENERGY Group
## Breeze vs. the Competition

<table>
<thead>
<tr>
<th>Feature</th>
<th>Others</th>
<th>Breeze</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focused completely on renewable energy software</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Single cloud-based web accessible system, no local programs</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>No versions to install, update or version history to keep track of</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Fair and non-complex pricing</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Mobile app and API for third party access and integrations</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Responsive sales and support people</td>
<td>?</td>
<td>YES</td>
</tr>
<tr>
<td>Fast moving innovator in the industry</td>
<td>?</td>
<td>YES</td>
</tr>
<tr>
<td>Open to new ideas from clients</td>
<td>?</td>
<td>YES</td>
</tr>
</tbody>
</table>
Electricity production from renewable energy is experiencing massive growth. Beyond growth, there exists a big upside in understanding the underlying often very volatile fuels and how they affect production levels and financial yield metrics.

We have seen production increases that have been realized after understanding how production assets perform in different weather conditions and tuning them accordingly. This of course requires IT systems that provide useful metrics - that is what we do.

Increased production levels is a good thing for many stakeholders:
1. Consumers get cheaper electricity
2. Owners get increased return on investment. Increased production levels have an almost direct impact on the bottom line.
3. The world gets cleaner electricity production

We find that creating products to provide insights that generate so much positive influence is an incredibly rewarding endeavour.

Jonas Corné, CEO of Greenbyte