





Montgomeryville, PA (HQ) (267)-421-5300 Boston, MA (781)-951-5300 East Greenbush, NY (518)-541-5300

Columbia, MD (301)-709-5300

sales@panaceatech.com

OpenPWR - Improving Wind Farm Operational Control and Intelligence

Introduction

With an increasing demand for renewable energy, Wind Energy has seen massive growth in line with other renewable energy sectors. The consolidation of wind farms has led to the rapid growth of wind farm portfolios, leaving many owners with a new set of challenges. With operators directing wind farms across the country or even the world, improving operations is at the forefront of corporate priorities [1].

Operating wind farms remotely can present a problem, especially when dealing with a wide range of turbine manufacturers with varying control and visualization platforms. These platforms can vary between sites or even between areas at the same site. Different visualization systems have different data standards and instrument naming, making data consolidation and analysis cumbersome. However, this sort of data analysis is vital to energy generation forecasts and other key economic markers. Consolidating these to a single platform is often an expensive and engineering intensive task.

Panacea Technologies has worked with their renewable energy clients to deploy a multisite cross-functional visualization platform, named OpenPWR, that provides uniform control and reporting regardless of turbine vendor or current visualization platform. When effectively deployed, OpenPWR consolidates cross-county and transnational sites on to a single platform allowing standardized company-wide monitoring and control of windfarms and associated turbines. The platform's Unlimited Licensing Model drastically reduces licensing costs and allows seamless scaleup and consolidation. Our current deployments have resulted in improved financial and performance metrics while vastly reducing annual licensing fees. Our deployments have also empowered companies to have greater access and visibility into their important assets. Panacea's OpenPWR is designed using Inductive Automation's Ignition, a powerful off-the-shelf software.

Consolidated Control

For many wind energy operators, operating turbines from multiple vendors across multiple sites can be a challenge. Individual turbine vendors may have different data standards and instrument naming, complicating data consolidation. Furthermore, remote access to the turbines can range from cumbersome or in the case of certain older turbines, impossible. Migrating multiple systems to a single platform can provide simple control, data consolidation, and remote access capabilities.

Corporate Level

At the highest level, OpenPWR's corporate view (**Figure 1**) aggregates site data to provide performance and financial metrics. These metrics can be used to determine key predictive and operational drivers including:

- Instantaneous production capability
- Hourly, daily and weekly production capability
- Optimum turbine mix
- Correlation between reliability and maintenance

Figure 1: Corporate View

Panacea Technologies Inc.					
	Montgomeryville (MTG) Emergency 1 Stopped 2 Running 1 Pligh Wind Low Prod 8 0 1	APC SP: 4000 KW APC SP (Ramping): 3460.0KW POI (Total Power): 4047.5KW			
	Estimated Hourly Production Capacity: Estimated Daily Production Capacity: Estimated Weekly Production Capacity: Optimum Turbine Mix:	31.53MWh 733.95MWh 5034.92MWh T12	Availability: Performance:	66.67% 49.18%	
'	optimum i urbine Mix:	112			
	East Greenbush (EGB)				
	Emergency Stopped Running High Windf Comm 1 3 10 1 1	POI (Total Power): 12919.5kW			
	Estimated Hourly Production Capacity: Estimated Daily Production Capacity: Estimated Weekly Production Capacity: Optimum Turbine Mix: A01 A12 A07 A10 A1	31.53MWh 890.34MWh 5920.76MWh 1 A02 A03 A06	Availability: Performance:	66.67% 35.52%	
	Boston (BOS) Emergency Stopped Running High Wind Comm 0 3 12 0 11	APC SP: 11,100 kW APC SP (Ramping): 11100 kW POI (Total Power): 102121kW			
	Estimated Hourly Production Capacity: Estimated Daily Production Capacity: Estimated Weekly Production Capacity: Optimum Turbine Mix: B01 C01 C02 B1	37.65MWh 912.64MWh 6069.06MWh	Availability: Performance:	75.00% 27.12%	
	орилия натоле міх. Вот сот сог от	0 009 004 003			

Site Level

Moving from the corporate view to a site-specific view, OpenPWR's robust interface allows for customized and tailored monitoring solutions to meet operational needs. In **Figure 2A** (page 3), the Site Level View provides a quick summary of the conditions and output of every turbine at a site as well as active alarms. All alarms are also archived in Alarm History as shown in **Figure 2B** (page 3). In **Figure 2C** (page 4), a graphical display of the communications fiber line within the site is shown. This helps to provide insight into the substation or fiber line related issues.

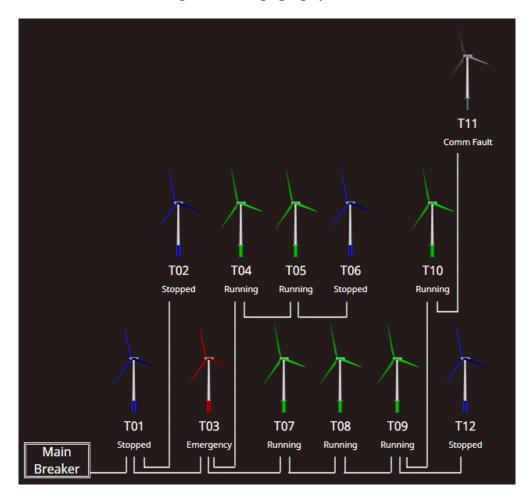
Figure 2A: Site Level View

Panacea Technologies Inc.	Imergency Stopped Hum 1 4 6 Overview Details	Low Prod Fault	3.40 kW Downtime Multi-Commands Login menogi: 2400.00W in Override F T	me
0.00kW	TOL + GE 123 SW 123	/s 7.12m/s 7.20m/s	121.22V 114.06V 120.74V	T11 V V 114.06V 4/3.53W/5 Comm Fault T12 V 124.98V 0.00WV Stopped
16 ACTIVE 0 SHELVED RLTERS (7): Active, Unacknowledged × 4 results within filters	Active, Acknowledged 🔀	cknowledged X) Priority: Low X)	Priority: Medium \times) Priority: High \times) Priority: Crit	Q = \$
Active Time 🗣 1	Display Path 🌲	Priority 🗘 2	State 🚖 3	Name 🚔
07/27/2020 10:30:49	Т02	Medium	Active, Unacknowledged	400 Overheating
07/27/2020 11:22:31	T07	High	Active, Unacknowledged	300 Dangerous Weather Conditions
07/27/2020 11:23:02	T11	Low	Active, Unacknowledged	100 Communication Fault
07/27/2020 11:24:30	тоз	Critical	Active, Unacknowledged	500 Emergency
10 rows 💌		First < 1 2	3 4 5 > Last	Jump to: 1

Figure 2B: Alarm History

Start Date:	Jul 24, 2020 11:38 AM Date:	Jul 2	7, 2020 12:38 PM				
22 alarm events	7/27					Q	÷ :
FILTERS (7): Active ×	Acknowledged X Cleared X Priority: Low	× Priority: Medium	Priority: High X	Priority: Critical ×			Remove
22 results within filters							
Event Time 🌲	Name 🚔	Event State 🌲	Priority 🌲	State 🌲	Display Path 🌲		
07/27/2020 10:10:49	400 Overheating	Active	Medium	Active, Unacknowledged	T02		
07/27/2020 10:26:25	100 Communication Fault	Active	Low	Active, Unacknowledged	т08		
07/27/2020 10:30:49	400 Overheating	Active	Medium	Active, Unacknowledged	T02		
07/27/2020 11:22:20	500 Emergency	Active	Critical	Active, Unacknowledged	тоз		
07/27/2020 11:22:31	300 Dangerous Weather Conditions	Active	High	Active, Unacknowledged	т07		
07/27/2020 11:22:40	100 Communication Fault	Active	Low	Active, Unacknowledged	T11		
07/27/2020 11:23:02	100 Communication Fault	Active	Low	Active, Unacknowledged	T11		
07/27/2020 11:24:30	500 Emergency	Active	Critical	Active, Unacknowledged	Т03		
07/27/2020 11:24:32	100 Communication Fault	Active	Low	Active, Unacknowledged	т03		
07/27/2020 10:10:12	400 Overheating	Ack	Medium	Active, Acknowledged	T02		
07/27/2020 10:10:12	100 Communication Fault	Ack	Low	Active, Acknowledged	Т06		
07/27/2020 10:28:54	400 Overheating	Ack	Medium	Active, Acknowledged	T02		
07/27/2020 10:28:54	100 Communication Fault	Ack	Low	Active, Acknowledged	T08		
07/27/2020 11:24:19	500 Emergency	Ack	Critical	Active, Acknowledged	Т03		
07/27/2020 11:24:39	100 Communication Fault	Ack	Low	Active, Acknowledged	T03		
07/27/2020 10:10:12	400 Overheating	Clear	Medium	Cleared, Acknowledged	T02		
07/27/2020 10:10:12	100 Communication Fault	Clear	Low	Cleared, Acknowledged	T06		
07/27/2020 10:28:54	400 Overheating	Clear	Medium	Cleared Acknowledged	T02		
25 rows 🔻			1				

Figure 2C: Topography View



Turbine Level

Digging deeper at the site turbine level, OpenPWR provides real-time remote monitoring of a specific turbine and it's related metrics and environmental data. At this level, the individual performance of each turbine can be monitored, shown in **Figure 3** (Page 5). General, grid, generator, gear box, and nacelle & rotor parameters for a specific turbine as well as related outdoor conditions can be quickly evaluated from this view.

Figure 3: Site Level Turbine View

Panacea Technologies Inc.	Emergency Stopped 4 Ru 4 Overview Details	6 0 Fault AP	CSP: 3400 kW Downtime Multi-Commands Login CSP (Ramping): 3400.0kW In Override I total Powerf: 1514.5kW In Override	
T04 ► 66 123 32V 5.56m/s 225.24kW Running				
General Parameters Auxiliary Active Power: Auxiliary Reactive Power: Pitch Angle: Total Filtered Power: Estimated Energy Produced since		135.14kW 108.11kVAr 1.00° 225.24kW 4.26MWh	Outdoor Conditions Ambient Temperature: Sonic Atmospheric Temperature: Estimated Air Density: Wind Direction: Wind Speed:	19.01°C 19.01°C 0.95kg/m3 0.67° 6.06m/s
<u>Grid Parameters</u> Grid Active Power: Grid Frequency: Grid Reactive Power: Grid Voltage:		4487.32kW 60.00Hz 3589.85kVAr 125.32V	<u>Generator Parameters</u> Generator Bearing Temperature (coupling side): Generator Bearing Temperature (non-coupling side): Generator Speed:	35.02°C 45.16°C 758.08rpm
<u>Gearbox Parameters</u> Gearbox Bearing Temperature: Gearbox Oil Particle Flow: Gearbox Oil Temperature:		64.36°C 2.14L/min 65.04°C	Nacelle/Rotor Parameters Nacelle Position: Nacelle Temperature: Rotor Speed: Rotor Temperature:	180.67° 25.36°C 0.70rps 52.51°C

Analytics and Data Management

Data management is vital to operations as site analytics generate millions of data points annually. OpenPWR is highly adaptable and can be configured to provide average data on 10-minute intervals, rolling averages, or continuously generated graphical displays. This data can be exported in various file formats including .pdf reports. These reports provide information tailored to stakeholders at the corporate or site level at defined time intervals.

The graph generator in **Figure 4** (page 6) allows for different configurations to be created, customized and saved.

Figure 4: Example of Customized Graph of Continuous Data



Downtime Analysis

Manually recorded downtime logs are labor intensive and prone to error. There is no guarantee the record is accurate nor that every outage was recorded [2]. By automating the downtime recording, OpenPWR's logs can provide a more robust analysis of the breadth and impact of both internal and external events. Detailed downtime logs provide information on the length, cause, and result of a downtime event. Each event is assigned to an Owner with crucial details, including:

- Curtailment
- Utility
- Turbine manufacturer
- Fault code

As seen in **Figure 5** (page 7), individual Downtime logs can be manually edited and changed. Multiple events can be selected and edited simultaneously or merged. Events can be split to divide the assignment of fault. Logs can also be manually added to the record.

Figure 5: Downtime Log

Panacea Technologies Inc.			1	4	6 0	Fault APC SP: APC SP: 1 POI (Tot	Ramping): 3400.0kW I Power): 2719.5kW In	Override	8					
automating your world			Ove	rview Details	Compare	Graph Top	ology Alarm H	listory Tickets	Downtime					
				Sta	rt: 2020/0	7/27 00:00:00				End: 2020,	07/27 2	3:59:59		
Manual Addition	Filter table.													
Update Events	Subsite	🗧 Turbine 🌲	StartTi	···· •	EndTime 🗘	David	ntimeFault 🗘	Deventions Con		DowntimeCode 🌲		Fault 🗘	Francisco de constatuíto 🚖	A
	WindFar			2020 11:13:54	07/27/2020 11:2			DowntimeCat Owner	egory 🚽	Safety		Manual Stop	EnergyLossMWh 🗘	Approval None
Joint go an	WindFar			2020 11:13:54	07/27/2020 11:1			Owner		Safety		Manual Stop	0	None
Split Event	WindFar			2020 11:12:20	07/27/2020 11.1	Wea		Owner		Safety		Lockout	3.50	None
Alter Approval		tart Time	07/27/	End Time (I		Downtim		Downtime Categ	202	Downtime Code		Fault	5.50	None
Alter Approval		2020 11:12:20		Select da		Weather	V	Owner	~	Safety	\sim	Lockout	✓ Update	Appro
Show Delete										(
•	WindFar	m T06	07/27/	2020 11:12:20		Wea	ther	Owner		Safety		Active Power Control	0.54	None
•	WindFar	m T03	07/27/	2020 11:12:20	07/27/2020 11:2	4:37 Wea	ther	Owner		Safety		Active Power Control	0.20	None
•	WindFar	m T02	07/27/	2020 11:12:20		Wea	ther	Owner		Safety		Active Power Control	0.53	None
•	WindFar	m T01	07/27/	2020 11:12:20		Wea	ther	Owner		Safety		Unknown	1.12	None
· · · · · · · · · · · · · · · · · · ·	WindFar	m T03	07/27/	2020 10:28:49	07/27/2020 11:1	2:20 Ecor	iomic Curtailment	Owner		Information		Active Power Control	0.18	None
Configure Options	WindFar	m T01	07/27/	2020 10:24:44	07/27/2020 11:1	2:20 Turt	ine	Manufacturer		Notification		Unknown	0.39	None
Configure Override	WindFar	m T12	07/27/	2020 10:23:01	07/27/2020 11:1	2:20 Turi	ine	Owner		Safety		Lockout	1.31	None
_	WindFar	m T01	07/27/	2020 10:22:08	07/27/2020 10:2	4:42 Turi	ine	Manufacturer		Information		High Wind/Low Production	0.03	None
•	WindFar	m T02	07/27/	2020 10:20:53	07/27/2020 11:1	2:20 Ecor	omic Curtailment	Owner		Information		Active Power Control	0.19	None
	WindFar	m T08	07/27/	2020 10:15:24	07/27/2020 10:2	6:25 Ecor	omic Curtailment	Owner		Information		Active Power Control	0.03	Review
Export Table	WindFar	m T06	07/27/	2020 10:14:53	07/27/2020 11:1	2:20 Ecor	omic Curtailment	Owner		Information		Active Power Control	0.22	None
•	WindFar	m T13	07/23/	2020 14:58:16		Ecor	omic Curtailment	Owner		Information		Active Power Control	0.01	None

Sorting these events by the Fault Owner generates detailed summaries, describing the energy lost due to each event. This can provide insight into the key causes and costs of the different downtime events, allowing the users to improve turbine availability and determine if an incident is part of a trend and if corrective procedures were followed.

The downtime log also allows for an Override Downtime Event. An Override Downtime Event automatically allocates every event during a set period to the selected fault – often weather for extreme weather events or utility for curtailment. **Figure 6** shows an example interface for setting up an Override Downtime Event.

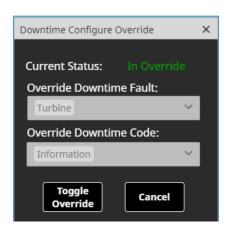


Figure 6: Example Override Downtime Event Setup

Licensing Model

OpenPWR's licensing model drastically reduces costs compared to other visualization packages. Licenses are designed to be a onetime cost and include deployment and integration of the platform, moving away from costly annual software subscription services. Instead of complicated pricing plans, licenses are based on site size and number of turbine technologies. As an example, a small site with less than 25 turbines of a single technology will have a deployment/license cost of \$90,000. A large site with more than 100 turbines consisting of three different turbine technologies will have a deployment/license cost of \$140,000. In both cases the

deployment/license cost includes setup, testing, licensing, and integration. Additional sites can be added for a fraction of the original cost as well. Optional service contracts provide access to updates and patches as well as software improvement deployment reducing annual service costs. Annual service contracts range between ten to fifteen percent of the deployment cost.

One license gives you an unlimited number of data points, and users, enabling it to be cost-effectively deployed on large systems, which is crucial in the competitive energy space. With an unlimited number of users, every person on every team can get access to the data and information that they need. With unlimited data points, there are no license-based limits to your data collection, allowing you to collect all required data to improve your operational success. Unlimited number of turbines enables your system to change size and adapt to your companies changing requirements. OpenPWR is streamlined for optimum performance to reduce the number of servers required for the system and can also be hosted on commercially available cloud servers.

Product Roadmap

Panacea is committed to continuous improvement and feature development of the OpenPWR platform. This includes operational, visualization, and functional improvements that will deployed to clients once tested and approved by Panacea's Quality team. An example of that is a Machine Learning module for OpenPWR's exiting Active Power Control module that is currently included. The Active Power Control module utilizes data on optimal power output from individual turbines to achieve power output setpoint in the most cost effective manner. We are developing a Machine Learning module to incorporate weather and power forecasting to better plan downtime and maintenance events in addition to a more agile method of automated turbine selection.

OpenPWR is compatible with Gemesa, Siemens, GE, Mitsubishi (MHI), and Vestas turbines. Our team can investigate adding additional manufacturers upon request.

Summary

OpenPWR provides a consolidated system that generates improved data that can be more quickly and easily translated into advanced analytics and key predictions. This helps to reduce operating costs, maximize energy production and revenue, improve predictability, and mitigate potential incidents. Automating alarming and downtime analysis provides a more consistent and accurate report, providing better indicators of problematic trends. OpenPWR empowers users to accomplish this and enables the cost-effective deployment of a consolidated visualization platform on even the largest of systems.

References

[1] Farren, Des. *Operational Intelligence for Renewable Energy*. ServusNet. https://www.ucd.ie/t4cms/ti12_d.farren_servusnet_11jun10.pdf

[2] Singh, Preetcharan. Analytical Techniques of SCADA Data to Assess Operational wind Turbine *Performance*. Department of Mechanical and Aerospace Engineering, University of Strathclyde, Faculty of Engineering. http://www.esru.strath.ac.uk/Documen

About Panacea Technologies

Panacea Technologies Inc. is a Process Control and Automation solutions company headquartered in Montgomeryville, PA with offices in East Greenbush, NY, Boston, MA, and Gaithersburg, MD. Panacea has been delivering cutting edge software solutions and services to our clients since 1996.

It is our mission at Panacea Technologies Inc. to provide our customers a competitive advantage by providing superior design, implementation, software, and management strategies to best leverage their automation and validation investments. Panacea Technologies' success is attributed to the confidence clients have in our technical know-how, diligence, and dependability.

Contact Panacea Technologies Headquarters at (267) 421-5300 or at <u>sales@panaceatech.com</u> to order or request an invitation to the next OpenPWR web demo, or to schedule a personalized product overview.