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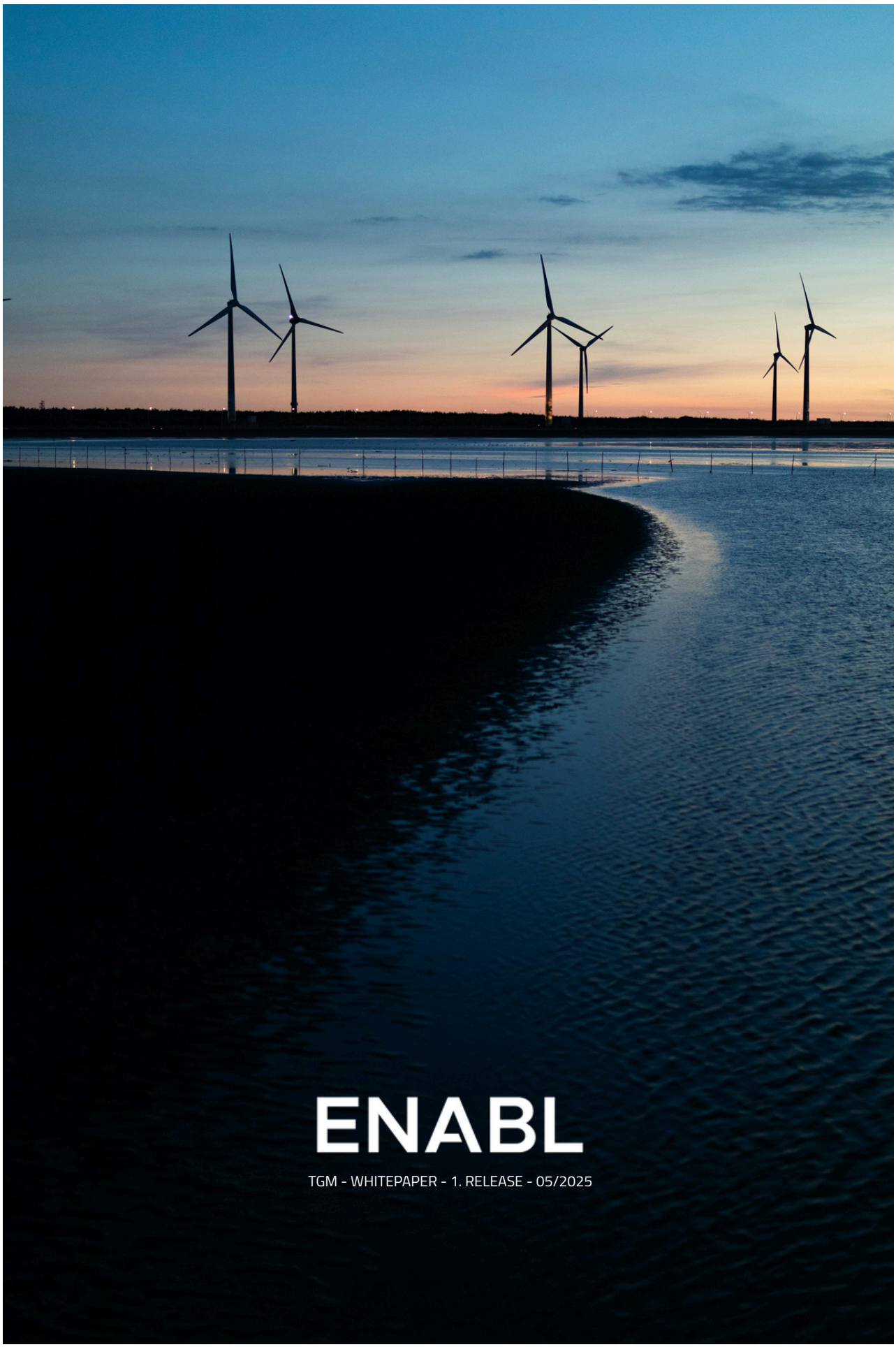
Overcoming Operational Window Constraints with Precise Load Stabilization & Enhanced Safety

Exploring Key Factors Impacting the Installation and Demobilization of Wind Turbine Components



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Content

Introduction

"Anything that can go wrong will go wrong,"

Murphy's Law aptly captures the challenges faced in wind turbine operations, especially when managing the installation and demobilization of large components with strict safety and stability requirements.

In the fast-paced wind industry, the "operational window" is crucial for determining the efficiency and success of turbine projects. It refers to the optimal timeframe for installation and demobilization activities, with direct impacts on financial outcomes and the levelized cost of energy.

As turbine sizes increase to meet growing energy demands, with average rotor diameters rising from 35 meters in 1991 to approximately 280 meters in 2023, operational windows are more critical than ever. By 2030, turbines are expected to produce up to 25 megawatts with rotor diameters over 350 meters (Source: Statista). These advancements necessitate not only longer operational windows for managing complex logistics but also robust safety measures to ensure stability and security.

Offshore projects rely heavily on costly jack-up vessels, making it essential to maximize uptime to mitigate financial impacts. This depends on integrating technologies that enhance weather resilience and extend operational windows. Additionally, ensuring safety and load stability is crucial from the outset, as larger turbines and offshore conditions demand robust measures to optimize uptime and safeguard against potential risks.

With the global wind market targeting a 30% cost reduction in the coming decade, maximizing operational windows is essential for balancing economic efficiency with environmental sustainability.

This paper aims to examine key factors affecting operational windows and to propose a solution to help wind projects in securing a large and safe operational window.

Factor #1 High-Wind Speeds

Wind turbine operations are particularly vulnerable to high wind conditions, with offshore sites facing even greater challenges. High wind speeds can destabilize lifting operations, especially for large components like WTG components, necessitating pauses to ensure safety. These interruptions lead to increased downtime and scheduling conflicts. Offshore installations confront additional difficulties due to inherently stronger winds, demanding robust risk mitigation strategies. Securing suitable weather windows is essential for maintaining operational uptime and cost efficiency.

Weather windows—defined as periods when wind speeds fall below 12 meters per second for at least 12 hours—are crucial for the safe and efficient installation of offshore wind turbines. Operating within these windows reduces risks and helps keep projects on schedule by having the wind turbine components as more stabilized suspended loads and less risky. However, sudden gusts can escalate operational hazards, highlighting the need for adaptive safety measures that accommodate instantaneous wind changes.

For crane operations, the safe wind speed is approximately 11.18 meters per second (25 mph), with gusts not exceeding 15.65 meters per second (35 mph) (Source: Science Direct). For lifts conducted both in port and on site, the focus is primarily on wind speed and gusts, with typical limits set between 10 to 15 meters per second. (Source: StormGeo). Exceeding these limits can significantly disrupt the installation of wind turbine components, thereby risking both safety and project timelines. This issue is especially pronounced in high wind potential regions like the US, India, and the Asia-Pacific, where wind speeds often surpass 10-12 meters per second (Source: StormGeo). These conditions can lead to involuntary operational halts.

That being said, high wind speeds already present a challenge by impeding uptime and affecting the overall weather window. To mitigate this, suppliers should focus on providing equipment that can perform optimally even at the highest wind speed limits. The suspended load should This ensures that the equipment itself does not contribute to a reduced operational window when weather conditions are favorable.

Did You Know?

In Koppal, Karnataka, India, it's customary to pause installations or demobilizations of wind turbines if wind speeds exceed 12 meters per second.

Factor #2
Limited Onsite Space

Onshore wind projects frequently encounter the issue of limited and shrinking hardstands, which impose significant constraints on crane mobility and equipment placements. With rising wind speeds and expanding blade sizes, these constraints are becoming increasingly pronounced. As a result, maintaining stability and precision during operations becomes more challenging.

These spatial limitations complicate logistics, leading to slower processes and a heightened risk of operational errors. Additionally, the safety of personnel is a primary concern in confined spaces where maneuverability is restricted.

Moreover, constrained space often necessitates cutting more trees to clear pathways, which may incur additional environmental fines and contribute to project costs. The impact on uptime and operational windows is significant; research shows that limited space can lead to extended project timelines by up to 20%, as teams must work around these logistical hurdles. Addressing these constraints through innovative design and planning is essential for enhancing operational envelope and efficiency, and maintaining safety standards in onshore wind projects.

Factor #3
Safety Measures

Safety should be viewed as the "common denominator" that, when integrated early, transforms from a potential constraint into an enabler of larger operational windows. Well-known rules, if adhered to meticulously, shouldn't hinder operations but rather promote stability and efficiency even in challenging conditions.

Ensuring compliance might sometimes seem to reduce operational windows, but when safety is ingrained in the design phase, it leads to safer and more efficient environments. Globally, safety compliance levels vary, with some regions like the United States enforcing stricter guidelines, while others may adopt more flexible standards (eg., India). Regardless, adherence to these safety protocols is considered best practice and crucial for optimizing operations

3.1
US OSHA's Safety Rules

The Occupational Safety and Health Administration (OSHA) provides comprehensive regulations to ensure safety in industries such as construction and energy, which involve high-risk operations like wind turbine installations.

Use of Taglines (OSHA 1926.1401)
The use of taglines in wind turbine installations is critical for maintaining control over large components during hoisting operations. OSHA standards only require the use of tag lines whenever their absence would create a hazardous working environment, as for instance in lifting such big components in high-wind speeds like a blade or a rotor. Tag lines are known to stabilize heavy loads, minimizing the risk of swings that could compromise safety and lead to project delays.

However, manual use of taglines introduces significant risks. Uneven tension can occur, resulting in communication breakdowns among teams and potential equipment malfunctions that threaten operational continuity. More critically, manual use of taglines exposes personnel to various hazards. Workers often lack an accurate sense of the tension applied, leaving them vulnerable to sudden, strong gusts of wind. Such conditions pose severe threats, including the risk of serious injuries like broken limbs if ropes snap at high speed.

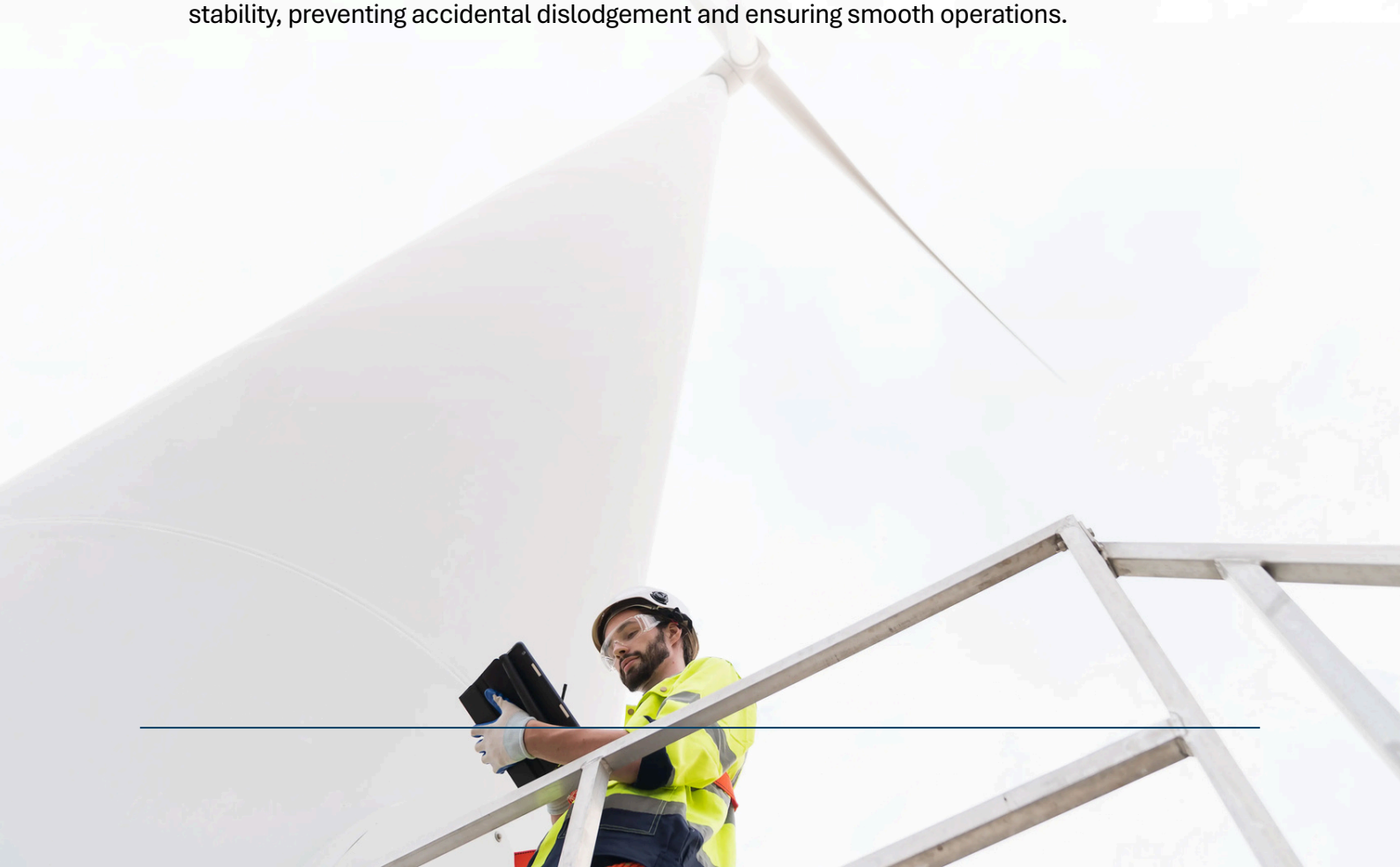
Although not always compulsory, taglines are highly effective tools for load stabilization during high wind speeds when utilized correctly, particularly with the integration of advanced technology. Automating tagline operations can significantly enhance operational efficiency by improving load control and minimizing delays. This approach helps increase uptime and extend the operational window, ensuring smoother and safer operations.

Other rules in connection to installation of WTG components can be found in OSHA **1926.1425 and 1926.1431.**

In WTG installation and demobilization, it is essential that all equipment operators are trained and certified. Regular testing of hoists and cranes is crucial, along with keeping loads clear of personnel by maintaining a "10-foot rule" around suspended loads. Remote controls should be used to ensure operators maintain a safe distance, load ratings must be verified, and thorough equipment inspections conducted. Items like buckets and forks should be securely stored on the ground when not in use to enhance safety.

These rules are summed up as:

- **Minimizing Exposure**: Workers should not be under suspended components, enhancing safety and preventing accidents.
- **Fall Zone Restrictions:** Only essential personnel should be in fall zones to minimize exposure to potential hazards and improve safety.
- **Secure Rigging:** Components should be rigged with self-closing hooks to maintain stability, preventing accidental dislodgement and ensuring smooth operations.



3.2
EU Safety Guidelines & Rules

The installation or demobilization of WTG components is also influenced by the European Union safety rules. It enforces strict safety to protect workers with regulations and directives focusing on equipment safety standards for lifting large loads.

Machinery Regulation (EU) 2023/1230
Although it comes into force in 2027, the EU Machinery Regulation 2023/1230 is already setting the stage for safer interactions between humans and machines. This regulation aims to promote the standardization of fundamental and mandatory European machinery safety requirements.
These rules state that all machinery must meet health and safety standards, securing CE marking to ensure reliability and reduce unforeseen project delays. Compliance mitigates risks associated with equipment failures, helping broaden operational windows.

Work Equipment Directive (Directive 2009/104/EC)
These rules under the Work Equipment Directive emphasize training and skilled operation to enhance safety and load stabilization. By ensuring only qualified personnel manage complex machinery, they effectively reduce errors and extend operational windows.

- Restricted Access and Expert Modifications: Equipment with specific risks must be operated by trained personnel, ensuring only qualified operators handle complex equipment, reducing the risk of operational errors.
- Training and Information: Comprehensive training on equipment use and risks ensures that all personnel are informed, promoting safer handling and efficiency.
- Impact on Operational Window: Proper training and equipment handling reduce errors and accidents, supporting efficient operations and extending the operational window.

These safety rules and standards serve as critical frameworks for operations, offering opportunities to refine practices and integrate safety into design.

Adopting the "prevention through design" philosophy ensures safety is central from the beginning of wind farm development. Supported by modern technologies, this approach can significantly extend operational windows, especially during the installation and demobilization of heavy loads like wind turbine components.

Next, we will explore how technology can embed safety from the outset and support continuous operations.

4. Transformative Solutions in Practice:

How the ENABL Tagline Master System (TGM) Overcomes Factors Affecting Operational Windows

Incorporating intelligent design and advanced technology into equipment like the ENABL Tagline Master System (TGM) can significantly enhance operational windows by addressing key challenges such as high wind speeds, limited spaces, and safety requirements. This approach ensures productivity, safety, and efficiency in wind turbine operations. For instance, TGM successfully completed a blade installation in just 28 minutes amid the relatively high-wind conditions of Texas, US. Let's explore how this is achieved and what makes TGM uniquely capable of such performance.

WATCH VIDEO HERE

4.1 Automation and Intelligence at Work

The ENABL Tagline Master System (TGM) is a pioneering solution that seamlessly integrates automation and intelligence to transform wind turbine operations. With precise tension sensing and coil sensing organs, TGM automates control by automatically adjusting tension to maintain a stable load position, reducing the need for human intervention in high-risk tasks and enhancing both safety and operational efficiency.

Complementing these capabilities, TGM offers real-time data and advanced data logging, which significantly enhance operational windows by providing immediate insights. The user-friendly system presents data in interpretable graphs and allows for seamless integration with tools like Microsoft Excel.

Additionally, remote support through Site Manager enables technicians to troubleshoot and configure the system from any location, minimizing downtime and ensuring consistent productivity. This comprehensive approach allows swift responses to anomalies, optimizing equipment performance and enhancing overall efficiency and safety.

Let’s explore how Intelligent and 100% Automated TGM helps to expand the operational window for each key factor:

4.2 Wind Speeds Never Present a Limit for ENABL TGM

First and foremost, the ENABL Tagline Master System sets itself apart by having **no wind speed limitations**, unlike other equipment on site. It is never the cause of interrupted operations at high wind speeds, as it can fully stabilize loads under any wind conditions.

TGM's advanced technology ensures unparalleled stability even in high winds, transforming gusts from a potential limitation into a manageable factor. Its intelligent systems, featuring precision tension control, maintain uninterrupted operation by automatically adjusting to changing conditions.

When onshore, utilizing two robust winches as its core, the Tagline Master System securely holds the load in place throughout the entire lift. This system elevates precision lifting by providing control over both **vertical and horizontal stabilization,** eliminating concerns about wind, crane movements, or other external disruptions.

The offshore TGM excels in high wind conditions with several features enhancing its capability. The Tagline Winch offers a pull control up to 120kN, delivering a force of up to 240kN on the load, while the Guidewire Winch supports up to 350kN with a 420kN brake force. It accommodates both rope and wire, making it versatile for different setups.

Once lifting begins, **TGM operates in fully automatic mode**, with built-in safety protocols that activate the brakes immediately in the event of any irregularity, ensuring continuous stability and security.

4.3
Limited Spaces Pose No Challenges for TGM

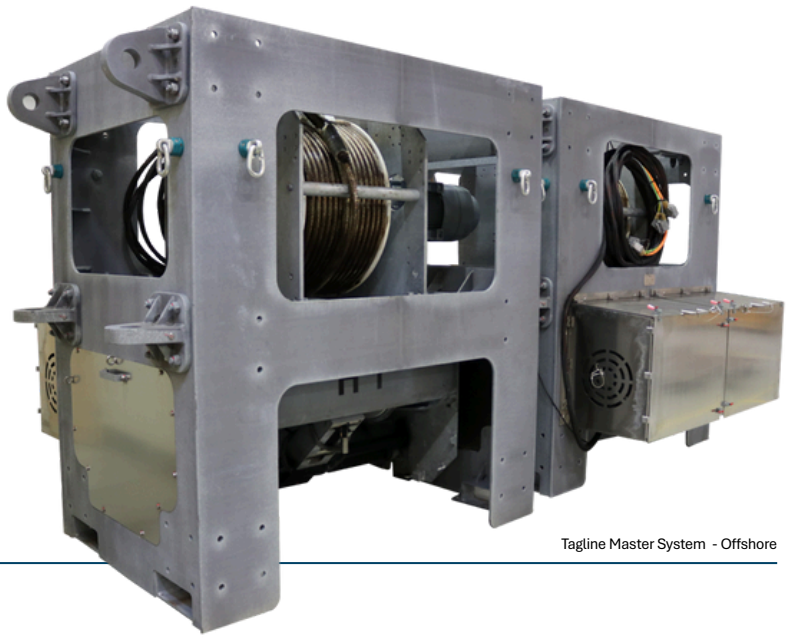
The Tagline Master System on Crane Ballast ensures superior stability even in high winds and challenging terrains, including small hardstands. By consistently aligning with crane movements, it provides complete stability from the initial component pickup to final installation. This innovative solution enhances flexibility and allows for swift, safe relocation. Consisting of only two units attached to the crane, the Tagline Master System is designed for optimal efficiency and ease of use.

Tagline Master System on the Crane Ballast

4.4
US OSHA asks taglines, ENABL TGM delivers

The TGM's fully automated and intelligent design not only meets but exceeds OSHA's tagline requirements. By maintaining automatic load orientation and tension, it provides a safer and more efficient alternative to traditional manual systems, effectively eliminating risks associated with manual tagline handling. This advanced system keeps personnel out of harm's way, mitigating the danger of being near falling lines if a rope were to snap.

In contrast, manual taglines often require personnel to control them by hand, even when using trucks or forklifts, which increases the risk of injury. TGM addresses these concerns by removing the need for manual intervention, significantly enhancing safety and operational efficiency.



Tagline Master System - Offshore

4.5
Safety First.
High Operational Window Next

The ENABL Tagline Master System (TGM) is designed with a multitude of safety precautions embedded in its equipment, either eliminating risks or significantly diminishing them.

- **Efficient Operations with Minimal Personnel:** TGM requires **only one operator, only on ground,** drastically reducing the number of people onsite. If integrating with ENABL Camera System, operators can manage installations remotely, significantly reducing the need for personnel under suspended loads. This technological combo enhances safety and operational control, allowing operators to work from a safer distance while expanding the lifting zone and providing broader operational visibility.

- **Mitigating Risks from Heights and Fall Zones**: Unlike other solutions, TGM eliminates the need for personnel to work at heights or under suspended loads, effectively reducing risks associated with fall zones and enhancing overall site safety.

- **Smart Load Management:** Connected to an anchor point, TGM has the capability to inform operators of the allowable tension, ensuring optimal load management and further mitigating risks.

- **Regulatory Compliance:** TGM adheres to stringent machinery regulations, carrying **CE marking and UL approval for the US market.** The system aligns with work equipment rules, requiring appropriate training and certification for operators, thereby ensuring both compliance and safety in operations.

4.6 Equipment Versatility

The TGM is engineered for versatility, making it suitable for a wide range of applications, including the effortless handling of **blades, nacelles, rotors, and tower sections**. This adaptability eliminates the need for extensive setup changes, ensuring continuous and efficient workflows. It also enhances precision lifting by providing control over **both vertical and horizontal stabilization.**

TGM can be easily adapted to different setups and tailored to specific needs with adjustable brake settings and pull settings, delivering unparalleled customization and control over lifting operations.

The versatility of ENABL TGM extends beyond the wind industry, finding applicability across various sectors, including construction, where managing suspended loads is essential.

Did You Know?
ENABL TGM is available for both **purchase** and **rent**, providing a flexible solution for those peak periods when you need to maximize installation windows and enhance project efficiency. Renting allows you to access the latest and safest equipment, ensuring high safety standards without the burden of ownership.

Get in Touch with Us!
Purchase: sales@enabl.dk
Rental: rental@enabl.dk

Tagline Master System - Onshore

Conclusion

Maximizing the operational window is crucial for the success and efficiency of wind turbine projects, particularly as the industry evolves with larger turbines and heightened energy demands. This whitepaper has highlighted key factors affecting operational windows, such as high wind speeds, limited onsite space, and stringent safety regulations.

By integrating intelligent design and innovative technologies, exemplified by the ENABL Tagline Master System (TGM), these challenges can be effectively managed. TGM's advanced automation, real-time data capabilities, and versatile applications not only meet regulatory standards but also enhance productivity and safety, ultimately extending operational windows.

As the global wind market aims for substantial cost reductions, embracing these solutions provides a strategic advantage, aligning technological advancement with economic and environmental goals. By addressing these operational factors head-on, stakeholders can ensure the continued growth and competitiveness of wind energy projects in an increasingly dynamic market.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