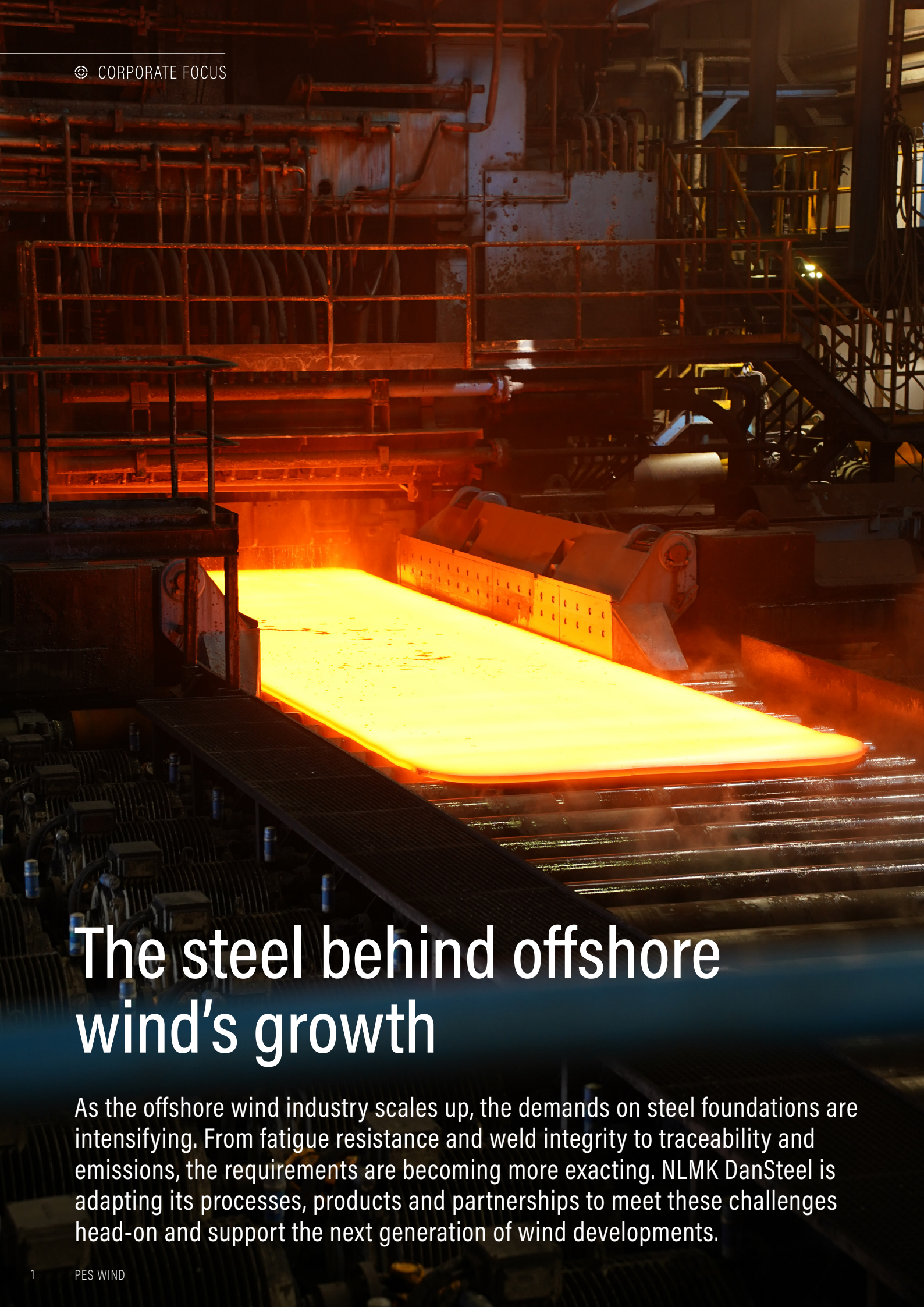

The steel behind offshore wind's growth

As the offshore wind industry scales up, the demands on steel foundations are intensifying. From fatigue resistance and weld integrity to traceability and emissions, the requirements are becoming more exacting. NLMK DanSteel is adapting its processes, products and partnerships to meet these challenges head-on and support the next generation of wind developments.

The heavy steel plate at the base of a wind turbine is a foundational yet often overlooked component of the energy transition. As turbines grow taller and move into deeper, harsher waters, foundation materials face greater complexity and performance expectations. In a sector racing to deliver on climate goals while grappling with supply chain disruption, bottlenecks and sustainability pressures, the role of high-specification steel is taking on a new level of scrutiny.

For heavy plate producers like NLMK DanSteel, this moment calls for proactive problem-solving. With a history that traces back to the earliest onshore towers, the Danish heavy plate mill has evolved its capabilities around the wind sector's most pressing pain points: manufacturability, certification, logistics, fatigue performance and, increasingly, emissions.

'We don't just make plates,' says Carsten Koch, Business Development & Customer Technical Service (CTS) Senior Manager, who has worked in the wind sector since 1996. 'We work with fabricators, classification societies and designers to help close gaps in supply, qualification and application. Wind is changing fast and the steel has to keep up.'

Fatigue, fabrication and foundations

One of the defining technical challenges today is fatigue. Offshore turbines experience a constant barrage of wave and wind-induced stress cycles. Monopiles and jackets, the steel structures that anchor turbines to the seabed, must endure for decades without failure. At the same time, the drive for scale means these structures are now pushing into plate thicknesses of 100 mm or more, with weight often exceeding 30 tonnes per plate.

'Beyond strength, it's the consistency across the entire plate that proves most critical,' explains Dr Eugene Goli-Oglu, Head of Product Development and Technical Sales Support. 'Variability in mechanical properties, grain microstructure or residual stress can become a weak point under cyclical loading. We've developed processing routes that aim to deliver uniformity across every dimension.'

Achieving this involves advanced TMCP (thermomechanical controlled processing) and ACC (accelerated cooling), microalloyed chemistries and tight process control. The resulting steels, such as S355, S420, S460 and others, offer high impact toughness at low temperatures and consistently excellent weldability, two attributes essential for offshore foundations.

Seam integrity is critical. Every additional weld increases labour time, quality control burden and potential structural risk. NLMK DanSteel's ability to supply wide and long plates reduces the number of welds fabricators must make. Fewer welds mean faster production, lower inspection costs and less chance of weld-related defects.

In the early days, NLMK DanSteel was part of pioneering efforts to design heavier and taller foundations. Koch recalls working with some of the first offshore monopile projects, including the London Array, a 175-turbine 630 MW offshore wind farm located 20 kilometres off the UK's Kent coast. At that time, the idea of an 8-metre monopile was considered outrageous. Today, diameters of 10 to 12 metres are the new standard.

Today, the steel plant can supply dimensions of up to 250 mm in thickness, 4,000 mm in width and 28,000 mm in length, positioning it well for future mega-projects.

Dr Goli-Oglu notes that customers routinely test full-scale welded samples, including tensile, hardness and notched impact tests of weld heat-affected zones. NLMK DanSteel supports these procedures, not just to demonstrate compliance but to validate that the steel performs as it should after a full industrial cycle.

Certification: the growing bottleneck

Another critical challenge for wind is certification. Before any prime steel is used in a foundation, it must pass stringent audits. This includes testing, documentation review and third-party validation by classification societies. The process can stretch into months, particularly for new grades, dimensions or producers.

'We understand that just good steel isn't enough,' says Dr Goli-Oglu. 'You need paperwork, traceability and precise, systematic pre-qualification.'

NLMK DanSteel maintains a portfolio of approvals from major classification bodies and works directly with customers to fulfil project-specific qualification requirements.

That includes Z35 testing for through-thickness ductility, impact testing at -40°C or colder and full weldability simulations under customer-defined parameters.

Logistics and sequencing: matching mill output to yard workflow

In large offshore projects, delivery sequencing can be a make-or-break issue. Plates must arrive in sequence to support fabrication. Any delay risks costly downtime.

In the London Array project and others since, NLMK DanSteel implemented a novel sequencing system in coordination with fabricators. Plates were delivered not just by project, but by section, aligned to the fabricator's build schedule. This meant fewer lifts, less storage and smoother progression.

'This isn't like shipping coils of commodity steel,' Koch says. 'We plan deliveries to match the customer's production plan, right down to how many lifts they need to make per day.'

Its location with direct sea, rail and road access enables this level of coordination. Some fabricators even receive plates packed in production sequence, streamlining assembly and minimising on-site handling. This close logistical alignment is increasingly vital as projects become larger and more modular.

Sustainability: the steel sector's high-stakes transition

While wind power is a key pillar of the low-carbon transition, its materials, particularly steel, carry a substantial carbon footprint. With more than 200t per MW of steel plates required for large turbines, steel is a significant contributor to the embodied carbon footprint of a wind project. Project developers have adopted ambitious supply decarbonisation plans.

NLMK Europe's response is its FORWARD30 strategy, a decarbonisation roadmap targeting a 30% reduction in Scope 1 and 2 emissions by 2030, and 90% across all scopes by 2045. A central component is the option to shift toward Electric Arc Furnace (EAF) steelmaking, using recycled scrap instead of primary ore.

The company has already delivered the first industrial batches of offshore-grade heavy plates made from EAF produced slabs at its Verona site. These plates have a carbon footprint as low as 0.73 tCO_2/t. That is less than one-third that of conventional BOF plate.

'We're looking at the options of expanding our EAF production capacity at NLMK Verona to increase the supply of low-CO_2 slab to NLMK DanSteel. If approved, this project would be a major step forward and a concrete boost to green energy infrastructure in the North Sea,' shares Tsanislav Kolev, Chief Business Development and Decarbonisation Officer at NLMK Europe.

The engineering challenge here is significant. Scrap-based steels often contain higher levels of copper, chromium, molybdenum and other tramp elements. Managing these requires advanced refining, tight casting parameters and process stability.

At Verona, vacuum degassing, ladle metallurgy and vertical casting allow NLMK DanSteel to receive high-purity EAF slabs suitable for thick plate rolling. The results have been verified through extensive testing, including impact energy performance down to -50°C and internal quality benchmarks like S3E4 ultrasonic EN standard.

'We've shown that you don't have to compromise on performance to cut carbon emissions,' says Dr Goli-Oglu. 'Our EAF-based offshore plates match the performance and reliability of traditional BOF-produced steels.'

Floating wind and northern conditions: the next possible frontier

Wind turbines are moving into deeper waters and colder climates. Floating foundations, which require greater flexibility and fatigue resistance, are pushing steel producers into uncharted territory. Northern and Arctic deployments demand materials that remain ductile below -40°C.

The company is already working on grades to meet these extreme requirements. Qualification involves not only lab testing, but often multi-year trials with project developers. That's especially true for floating wind, where structural dynamics are fundamentally different.

Carsten Koch points out that DanSteel was part of one of the first floating wind pilot projects in the middle climate zones. Although the initial trial with suction bucket anchoring didn't commercialise, the material lessons proved valuable.

This has recently included supplying materials for new fixed foundations and floating projects under development in the US and Northern Europe.

'These are not modifications of existing grades. They are entirely new solutions built from the ground up,' explains Koch.

In the Northern and Arctic zones, too, the company is preparing. Eugene notes that standards for Arctic-capable steels are only now starting to emerge, with requirements for validated toughness at lower temperatures. NLMK DanSteel is investing in metallurgy and testing to fulfil those expectations.

Making the most of cross-sector experience

Part of the company's capability in responding to wind sector challenges stems from its experience in other demanding markets, including pressure vessels, shipbuilding and civil engineering. Techniques for weldability, cleanliness and plate flatness developed for those sectors are adapted into wind-specific applications.

This cross-pollination helps accelerate innovation cycles, particularly as more developers seek to reduce fabrication risk. 'We understand the tolerances and testing regimes across sectors,' Dr Goli-Oglu notes. 'That insight helps us move quicker when a new requirement arises.'

Strategic investment: building capability and capacity

Much of its responsiveness is the result of long-term investment. Since 2008, more than €200 million has been spent upgrading the mill's core production systems. Notable improvements include a new reheating furnace installed in 2022, capable of processing slabs up to 63 tonnes; ACC line that enables precise temperature control during plate cooling; modern non-destructive testing systems for real-time quality monitoring; and expanded automation for tracking plate identity and ensuring full traceability.

'We took the strategic decision to focus on wind more than a decade ago,' says Koch. 'These investments reflect that and are targeted at the demands of large, technically advanced projects.'

Partnership, not just supply

'We're in constant dialogue with fabricators, EPCs and classification societies,' says Koch. 'We do not wait for the specification to arrive. We start planning months in advance, often improving it before it lands.'

This proactive approach extends to in-market support. NLMK DanSteel maintains local representatives in Denmark, Spain, France, Germany, the UK and Poland, ensuring customers can get technical and logistical support in their native language.

Matching ambition with material reality

The scale of global wind ambition is vast, but so are its engineering challenges. As turbines get bigger and deployment sites become more remote, the demands on steel plates continue to evolve. Fatigue resistance, low-temperature performance, weldability, traceability, logistics and emissions: all are now mission-critical.

With offshore wind evolving at speed, NLMK DanSteel's material innovation, proactive support, and long-term vision are helping ensure steel foundations are as future-ready as the turbines they support.

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