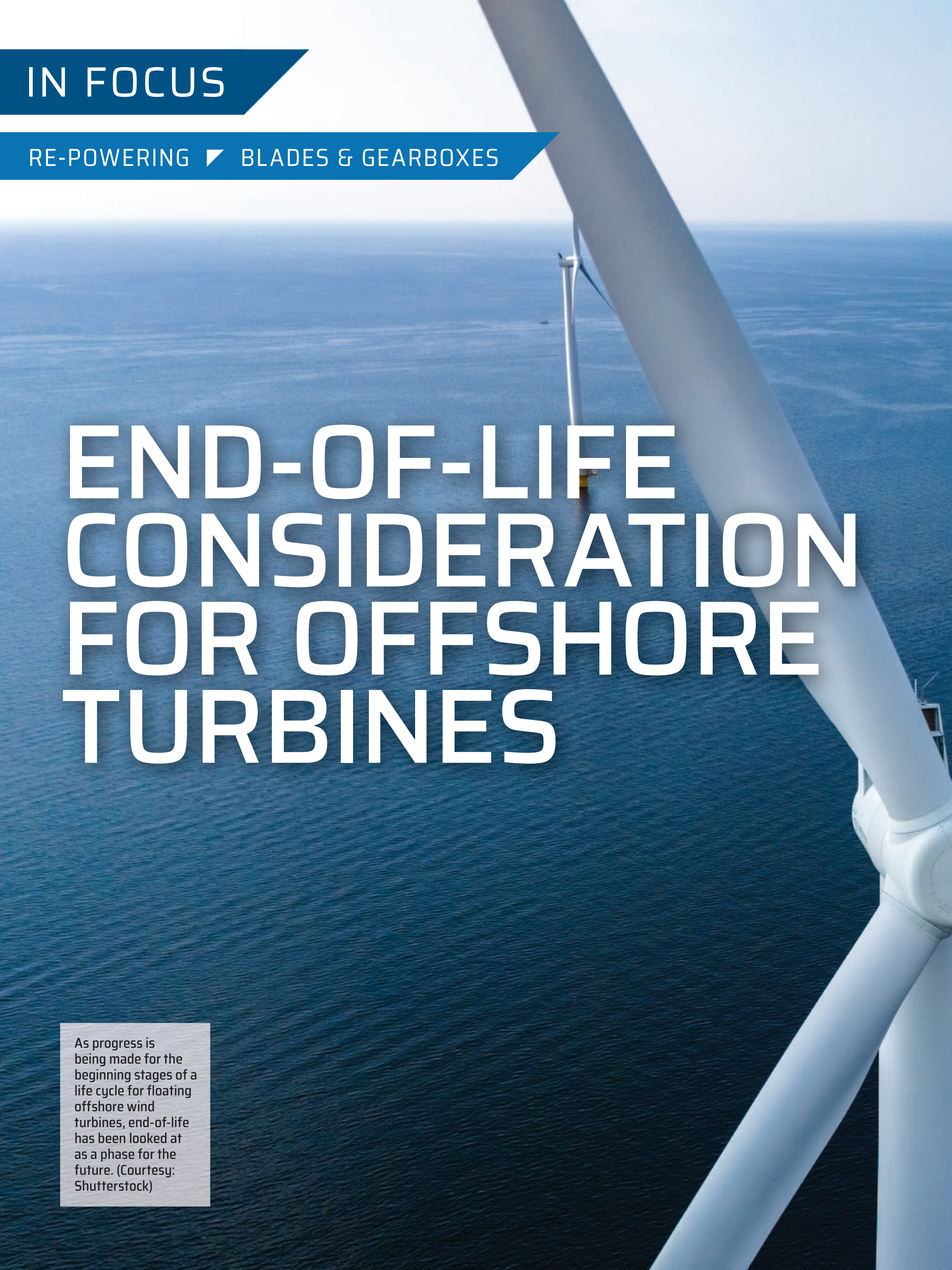
END-OF-LIFE CONSIDERATION FOR OFFSHORE TURBINES



As progress is being made for the beginning stages of a life cycle for floating offshore wind turbines, end-of-life has been looked at as a phase for the future. (Courtesy: Shutterstock)

Digital twin technology has the potential to increase the lifespan of floating offshore wind turbines through re-powering methods.

By PAYTON MADDALONI

With Mother Nature's clock ticking and as the climate shifts, renewable energy has become a heightened priority. The goal toward sustainable infrastructure is clear, but the road to get there is full of obstacles. Technology, as well as policy, has been developed to guide energy consumers in the right direction. However, the untapped market of the floating offshore wind turbine (FOSWT) has not yet begun on this journey. The primary assessment of the source's life cycle has been heavily discussed in the industry, but the end-of-life phase has been seen as an issue for the future. With tools and policy further discussed, they can be used in combination to not only extend the life of FOSWT farms but help limit the Earth's unnatural progression.

Karen Wilcox from the University of Texas, Austin reported on a technology that has the potential to increase the lifespan of a FOSWT. A digital twin is a personalized dynamic model of a physical system [8]. This can be compared to an Apple Watch for a human [8]. The watch creates personalized models based on the data collected from one's daily activities. These models adapt over the course of someone's life to then be used to form predictions on future behaviors. This technological methodology has been translated over into physical structures in the form of digital twinning. The concept has received backing from software and renewable energy companies including Bentley Systems, Siemens, and Nvidia.

Figure 1: Construction worker placing Iot sensors [7].

Figure 2: Design of the VolturnUS [9].

EXPLORING DIGITAL TWIN TECHNOLOGY

Industry has been exploring digital twin technology in the form of sneakers and bridge removal. ASICS is using their digital shoe models and real-life data from feet to bridge the gap for the Perfect Consumer Product [6]. ASICS acknowledges that no two people have identical feet, and the digital twin software allows this mass customization. Each customer can have their shoes tailored not only to their lifestyle but to satisfy what their whole-body needs.

Additionally, the City of Denver used Bentley Systems iTwin Iot Software to monitor bridge vibrations [7]. There were 16 sensors placed, feeding the city a steady stream of data of bridge movement [7] shown in Figure 1.

Rather than rely on yearly inspections, specific movements that exceeded a design threshold would be flagged and brought to immediate attention. This allows the city to keep up with maintenance not based on anticipated routine but daily statistics, limiting the amount of bridge closures due to unforeseen damages. The digital twinning software concept has been brought to life in many forms and making it transferable to floating offshore wind turbine maintenance with the possibility of end-of-life extension.

FLOATING OFFSHORE WIND

The floating offshore wind turbine industry has tremendous opportunity since President Joe Biden's climate agenda back in 2021 was given the federal greenlight. The race to launch a floating wind farm began and companies are backing researchers to experiment with their designs. California and Maine have made the most headway toward officially launching farms along their respective coastlines. In May 2024, Maine received approval to lease out coastal waters 45 miles from Portland with 12 turbines with 144 MW of energy [1]. This will allow researchers to not only study the area but interactions with the marine environment, fishing industry, and navigation routes. The University of Maine is at the forefront of design with their patented technology known as the VolturnUS. This design was based on the shape of an upside-down bridge shown in Figure 2 [1].

In June 2024, RWE-backed survey work began off the coast of Northern California [2]. UV (autonomous underwater vehicles) were used to conduct the surveys including the determination of where anchors, cables, and the actual turbines will be placed [2]. The site is 28 miles off the coast of Humbolt County and has the potential to power 65,000 homes with 1.6 GW of clean energy [2].

END-OF-LIFE PHASE FOR TURBINES

As progress is being made for the beginning stages of a life cycle for FOWT, end-of-life has been looked at as a phase for the future. This leaves a wide door open to massive experi-

Digital twin technology has the potential to increase the lifespan of floating offshore wind turbines. (Courtesy: Shutterstock)

mentation with potential end-of-life extension and disposal. The United States currently does not have a fleshed-out plan for decommission or extension, but it has been described that NOAA would be the regulatory body. NOAA works as the consultant providing baseline data and analysis on ocean impacts and conditions to the Bureau of Ocean Energy Management [3]. In related renewable energy sectors (onshore wind), the United States uses a method coined re-powering, which can be compared to the idea of retrofitting [4].

The process can extend the life of a wind farm but must be spearheaded by project owners. An example of a successful re-powering can be found in Mendota Hills, Illinois [5]. The re-powering required the decommission of existing wind-turbine generators and the installation of new foundations [5]. This increased the capacity from 50 MW to 76 MW and generated 250 jobs. Re-powering polices for onshore wind can be translated into the floating offshore wind sector, helping to flesh out a plan for the end of life phase.

OPTIMIZING THE GRAVE PHASE

Digital twin technology has the potential to increase the lifespan of a FOSWT. Optimizing the grave phase can help clear a path toward a brighter future for the energy source. The digital twin technology coupled with the U.S.-known re-powering methods would allow FOSWT farms to extend past the standard 25-year life span. This would not only help run the farm efficiently but create jobs through the re-powering program and lower the annual O&M. This can be seen as a one-sided benefit leaning toward the owners; however, the extension expands the lifecycle of the farm producing more renewable energy. With a combination of these two elements alongside the strides in U.S. policy, the future of FOSWT full LCA analysis is more tangible than ever.

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ABOUT THE AUTHOR

Payton Maddaloni is a recent graduate from the University of New Hampshire who balanced an honors civil engineering curriculum and a Division 1 sport. Maddaloni started her career as a project engineer at Gilbane Building Company in its Boston office while also researching for her alma mater part time.