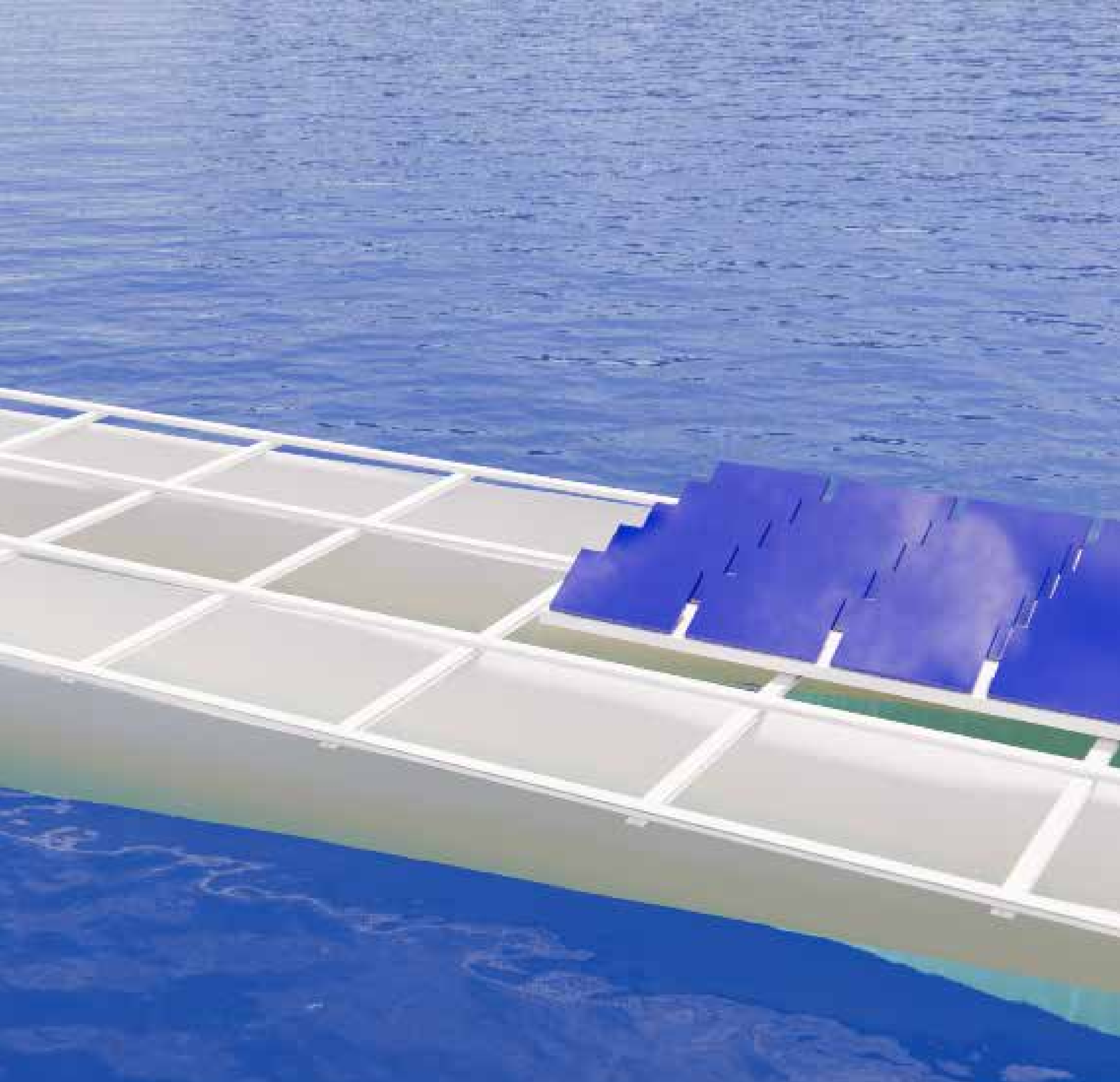

RE-WIND
NETWORK
BLADE REPURPOSING SOLUTIONS
WWW.RE-WIND.INFO

Re-Wind Design Catalog 2nd Edition Fall/Autumn 2022

Welcome to the *new* Fall 2022 Re-Wind Design Catalog!

The Re-Wind Design Catalog presents designs and details of structures and products made from End-of-Life repurposed wind turbine blades that are available from the Re-Wind Network.

New to the Fall 2022 edition is a section on Marine Structures (floating PV platforms, jetties and buoys), and new pages on Single-Girder Bridges, as well as, images of our recent BladeBridge installations in Cork, Ireland and Draperstown, Northern Ireland, UK. Models based on a SGRE B45 blade have also been included.

The Re-Wind Network is a network of faculty, staff and students at five academic institutions - Georgia Institute of Technology, University College Cork, Queen's University Belfast, City University of New York and Munster Technological University - and industry affiliates. On the web at www.re-wind.info

Models of the blades used in the designs were produced at the Georgia Institute of Technology using in-house software from LiDAR scans or documentation of five decommissioned wind turbine blades. Graphics were produced in Rhinoceros® and Enscape™ software. The blades used in the designs are listed below. They represent typical sizes and lengths of blades currently coming out of service throughout the world.

1. 13.4m LM blade from a Nordex N29 250 kW turbine.
2. 21m blade from a Vestas V44 600 kW turbine.
3. 37m blade from a General Electric GE 1.5-77 1.5 MW turbine.
4. 46.7m blade from a Liberty Clipper C96 2.5 MW turbine.
5. 45m blade from a Siemens Gamesa SWT-2.3-93 turbine

T*o contact us go to:* https://www.re-wind.info/contact

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Re-Wind Sponsors and Industry Affiliates: National Science Foundation (US), Science Foundation Ireland, Department for the Economy (NI), ENEL Green Power, Logisticus, Everun, Ltd, Cork County Council, Siemens Gamesa Renewable Energy (SGRE), Hubbell Power Systems, Inc.

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The Re-Wind Advantage

The Re-Wind Network provides architectural design, structural engineering analysis and design, and construction management and logistics services to those wishing to repurpose their End-of-Life wind turbine blades. The Re-Wind Network will work with a client to:

1. Develop architectural concepts and designs for potential repurposed structures.
2. Construct an exterior surface model of the blade in Rhinoceros® from LiDAR point clouds or manufacturer documentation of the blade.
3. Construct a "thick" engineering analysis model of the blade from internal point clouds, physical measurements and in-house algorithms.
4. Conduct selected testing of materials extracted from the blade to provide the physical and mechanical property data for a blade.
5. Provide Finite Element Analysis (FEA) models for two and three dimensional analysis of the entire blade or parts of the blade for use in third-party finite element method (FEM) codes.
6. Provide engineering section properties (EI, EA, GJ, kAG) of the blade at selected locations for use in third-party structural engineering codes.
7. Conduct structural and stress analysis of the repurposed structures made from the blade including all connections and attachments.
8. Perform full-scale testing of prototypes of the repurposed structures made from the blade.
9. Perform site investigations and recommend foundations and support structures for the repurposed structures.
10. Provide construction cost-estimates, Life Cycle Costs (LCC) and Life Cycle Assessments (LCA) of the repurposed structures made from the blade.
11. Provide on-site construction management during construction of the repurposed structures.

Re-Wind Publications

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A.J. Nagle, L.C. Bank and P.G. Leahy, 2020, "A Comparative Life Cycle Assessment between Landfilling and Incineration of Waste from Decommissioned Irish Wind Turbine Blades," *Journal of Cleaner Production*, Vol 227, https://doi.org/10.1016/j.jclepro.2020.123321

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L.C. Bank, R. Gentry, E. Delaney, J. McKinley and P. Leahy, 2021, "Defining the Landscape for Wind Blades at the end of their Service Life," CompositesWorld, Vol. 7, No. 5, pp. 6-9, June, https://www.compositesworld.com/articles/defining-the-landscape-for-wind-blades-at-the-end-of-service-life

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K. Ruane, Z. Zhang, A. Nagle, A. Huynh, A. Alshannaq, A. McDonald, P. Leahy, M. Soutsos, J. McKinley, R. Gentry and L. Bank, 2022, "Material and Structural Characterization of a Wind Turbine Blade for use as a Bridge Girder," *Transportation Research Record*, Washington DC, 03611981221083619. https://doi.org/10.1177/036119812210836

Ammar A. Alshannaq, John A. Respert , Lawrence C. Bank, David W. Scott, T. Russell Gentry, 2022, "As-Received Physical and Mechanical Properties of the Spar Cap of a GE37 Decommissioned GFRP Wind Turbine Blade," *ASCE J. of Materials in Civil Engineering*, 34 (10), 04022266. https://doi.org/10.1061/(ASCE)MT.1943-5533.0004410

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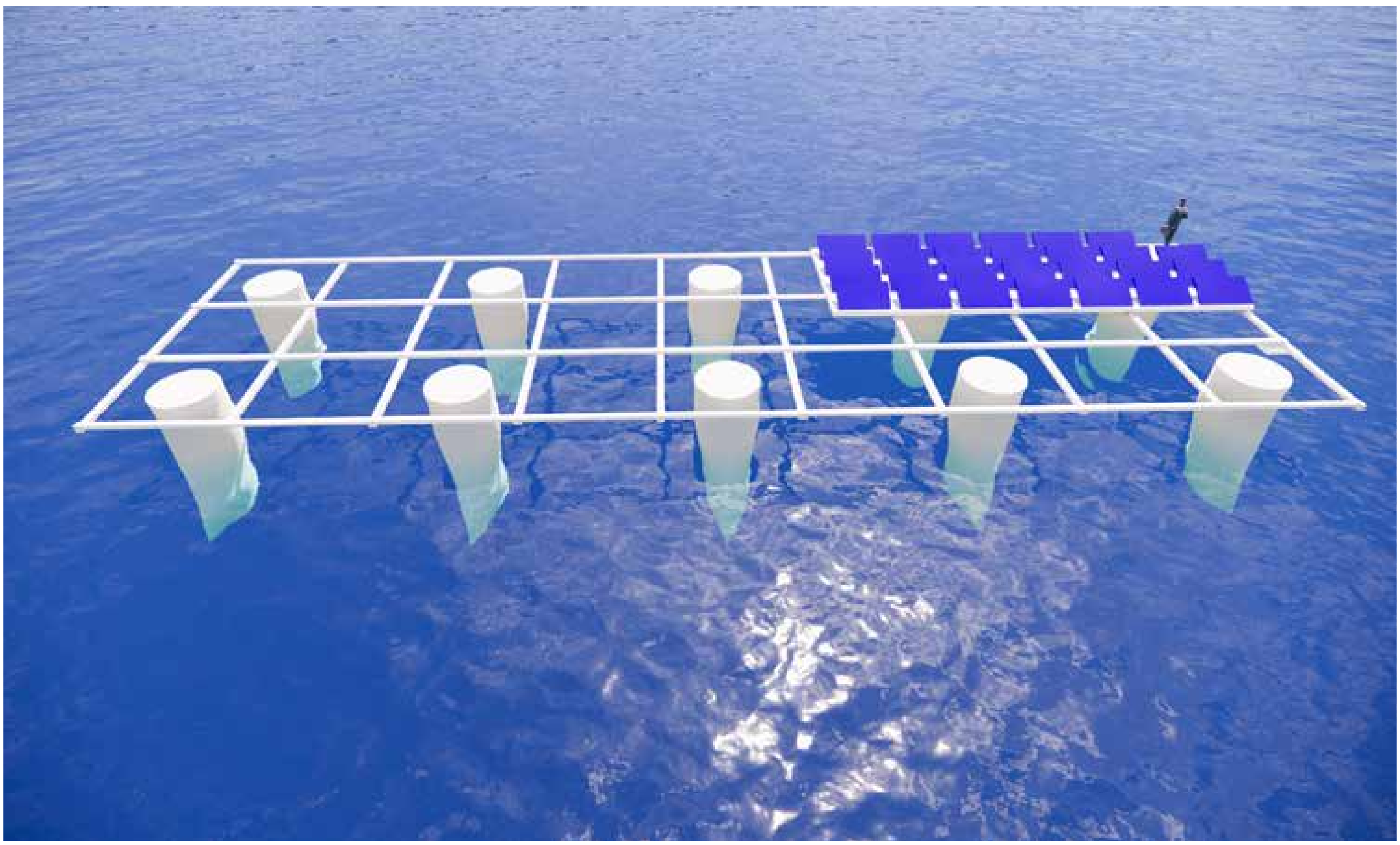
BladeMarine



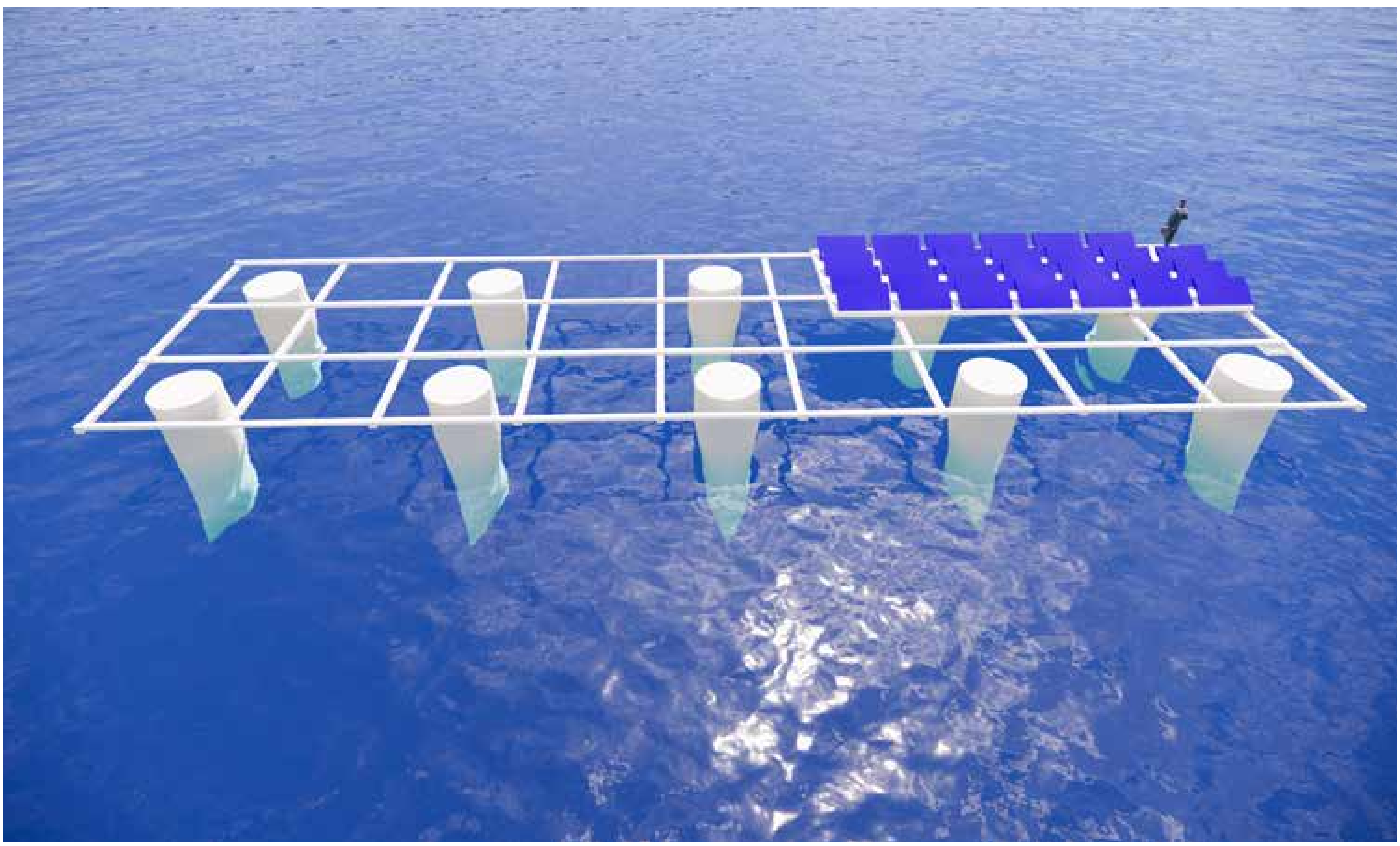
Wind turbine blades are ideal for use in the marine environment since the FRP materials do not corrode or degrade. Since they are hollow they also float. In addition, they are ideally located for building marine structures when off-shore or coastal wind farms are decommissioned.

Blades can be used to build many different floating or standing marine structures such as platforms, docks, piers, jetties and buoys.

Examples of platforms docks and jetties constructed of GE 37m blades and Clipper 46.7m blades are shown in what follows.

BladePlatforms can be constructed with the blades oriented horizontally or vertically or both. When the blades are oriented vertically they can either float in deep waters or be fixed to the sea bed in shallow waters.

BladePlatform



Large floating platforms are of special interest as they are often used to carry very large photo-voltaic (PV) solar arrays - called "aqua-solar" or "floating PV." Wind blades can be readily used to construct such floating platforms. Examples of such platforms made from GE 37m and 46.7m Clipper blades are shown.

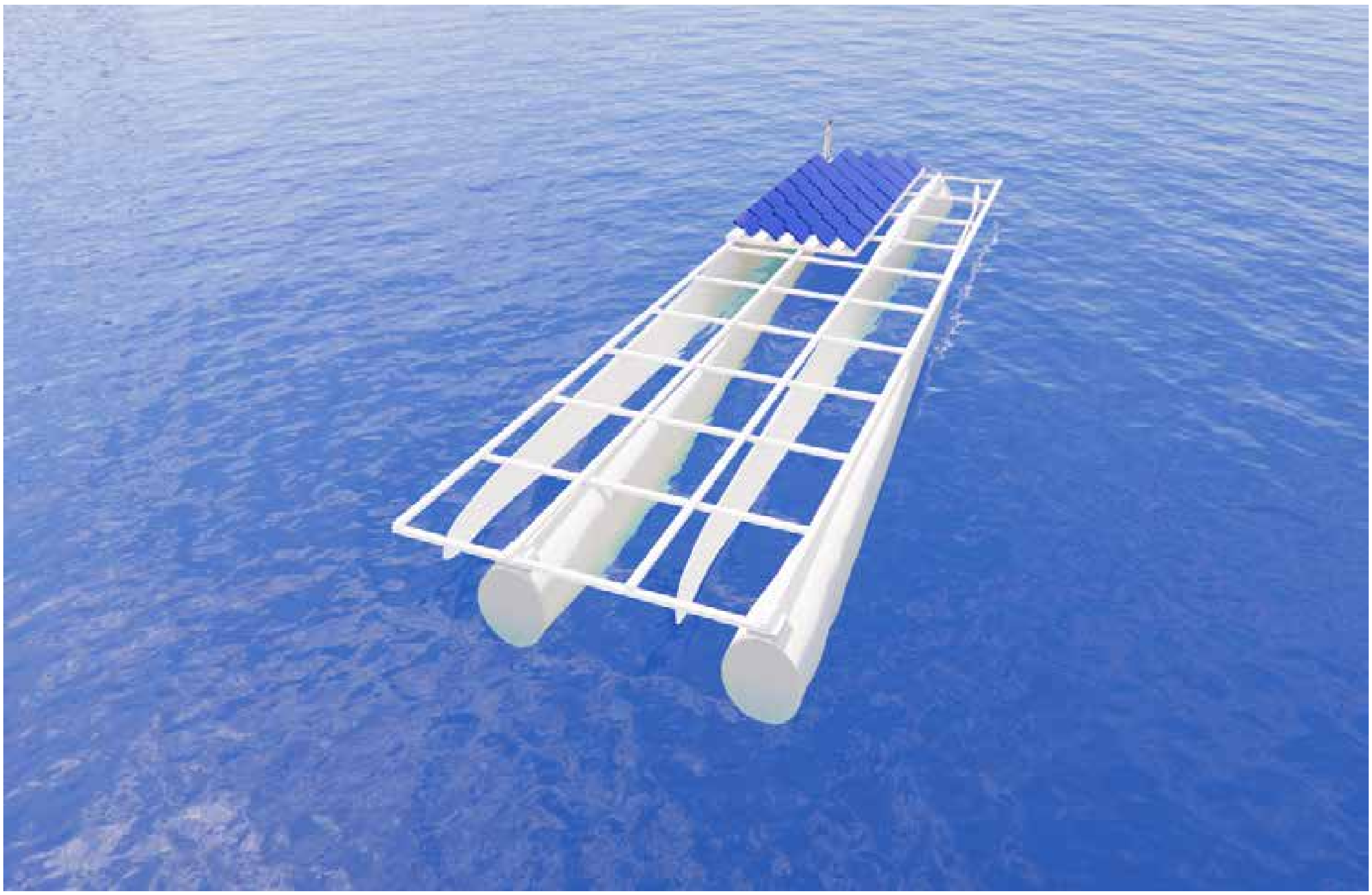
Floating PV structures with the blades oriented horizontally and blades oriented vertically are shown. When the blades are oriented vertically they need not be full length and can be truncated. In shallow waters the blades can be truncated and used as columns or piles and fixed to the ground.

It should be also noted that the platforms that are fixed to the ground can also be used on land as parking canopies or large roofing systems much like long span truss-joists.

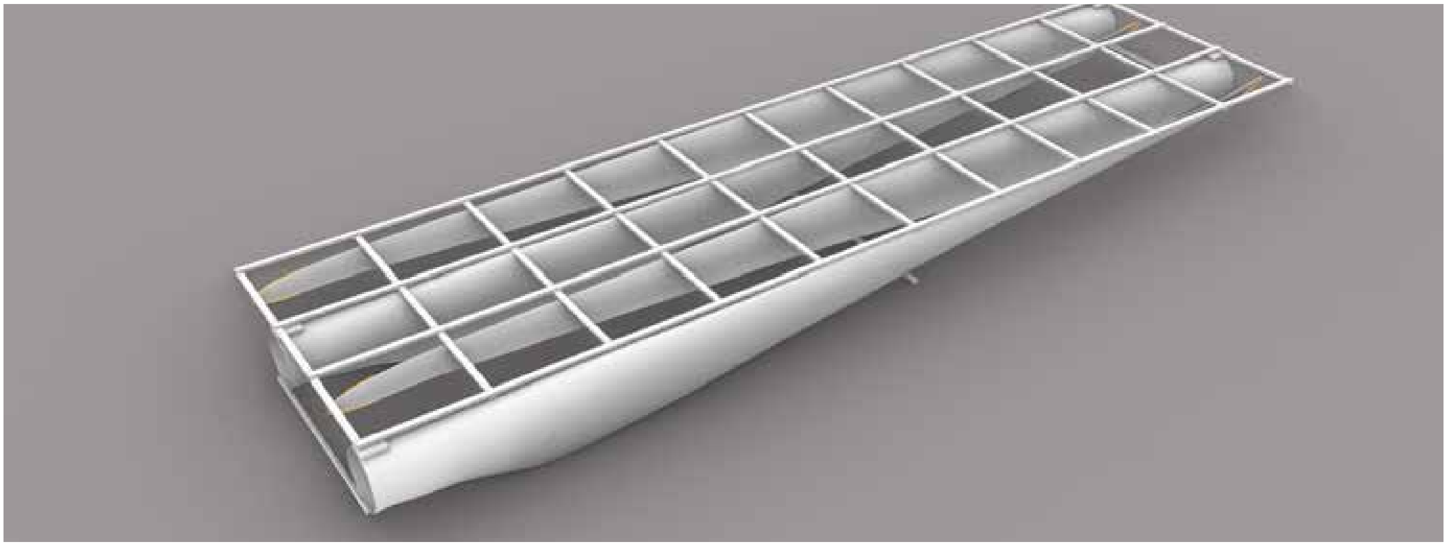
37m length–10m width

Horizontal Asymmetric Full-length GE37 Blades

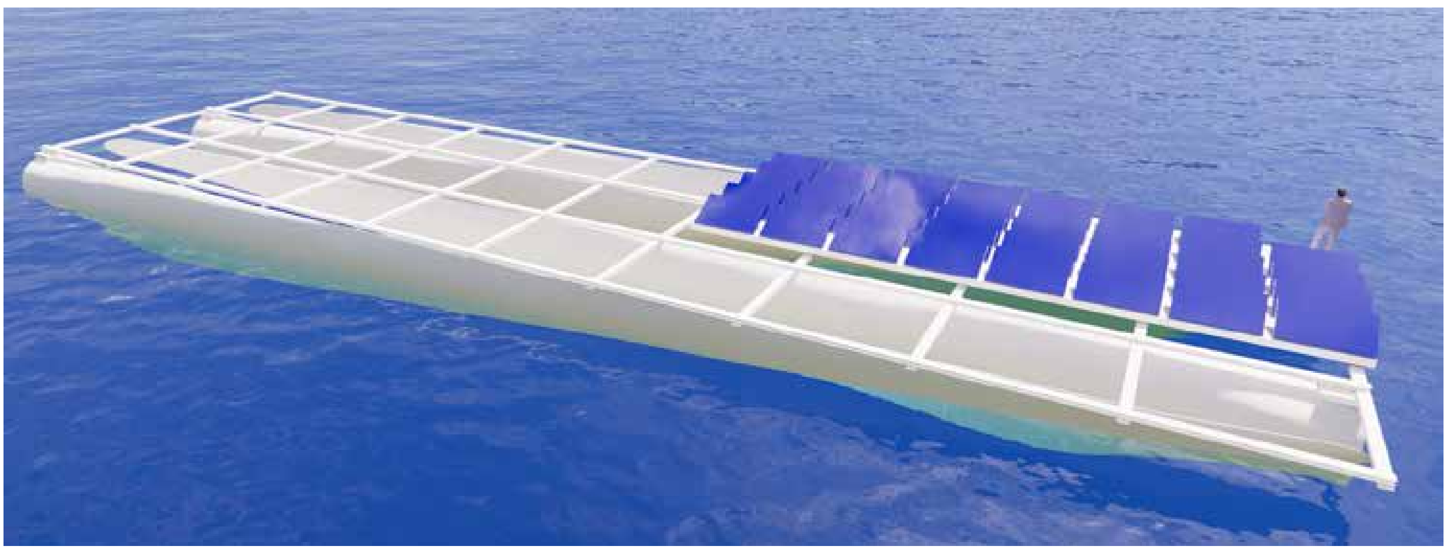
Pultruded FRP grid for carrying PV panels



The image above shows a 37m long by 10m wide floating platform for carrying photo-voltaic (PV) solar panels. Most floating PV farms are in shallow waters and near shore and are moored to the ground with cables and anchors. Power transmission cables run to the land either on the sea bed or on the platform. Larger surfaces can built by connecting individual units together.



The rendering above shows the grid constructed from pultruded FRP profiles bolted length- wise and cross-wise to the blades.

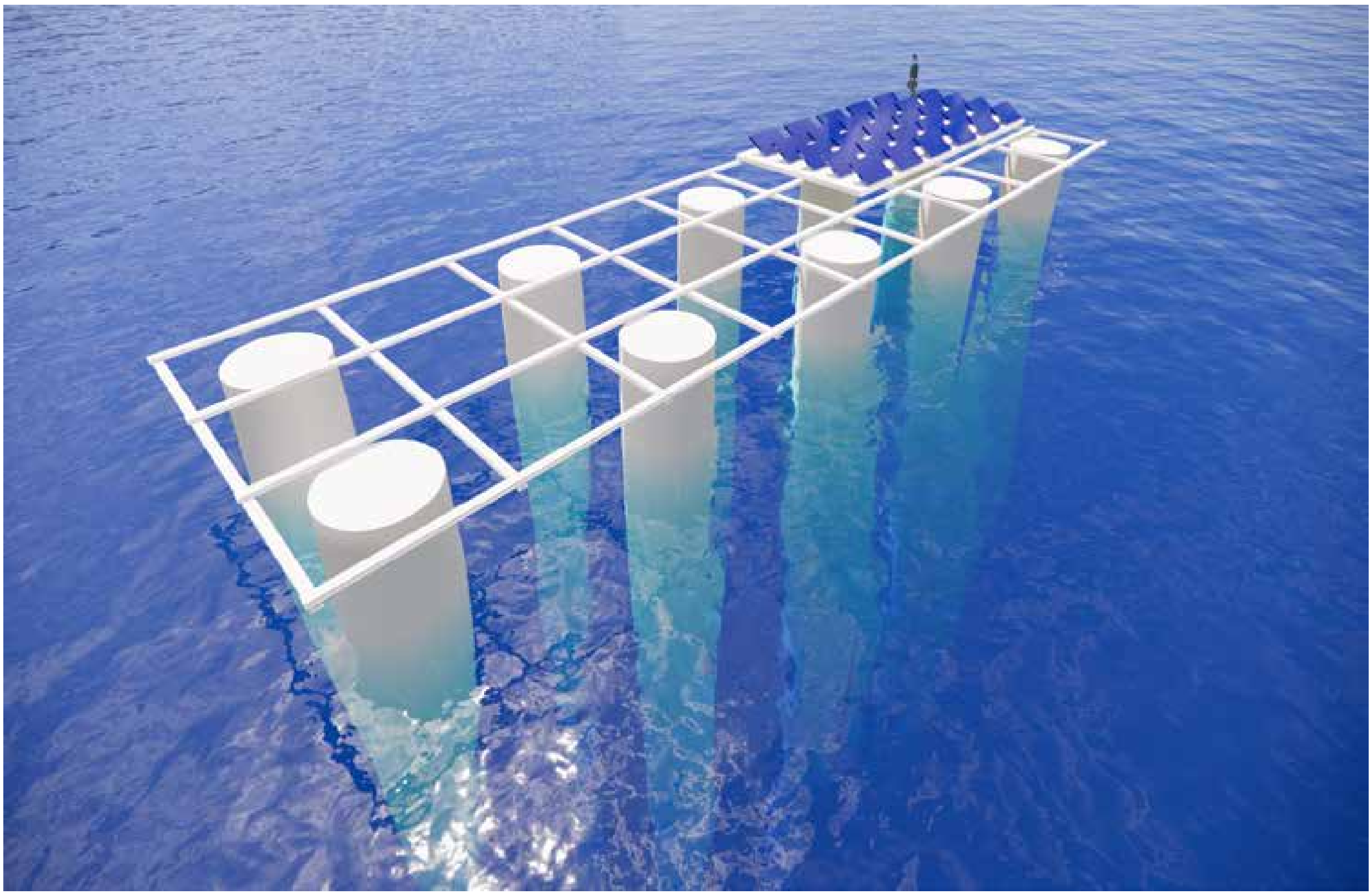


Side view showing the water level. Buoyancy calculations show that the blades float at about mid-root height when the PV payload is included.

45m length - 15m width

Vertical Symmetric Full-length C96 Blade

9 by 3 bay pultruded FRP grid for PV panels

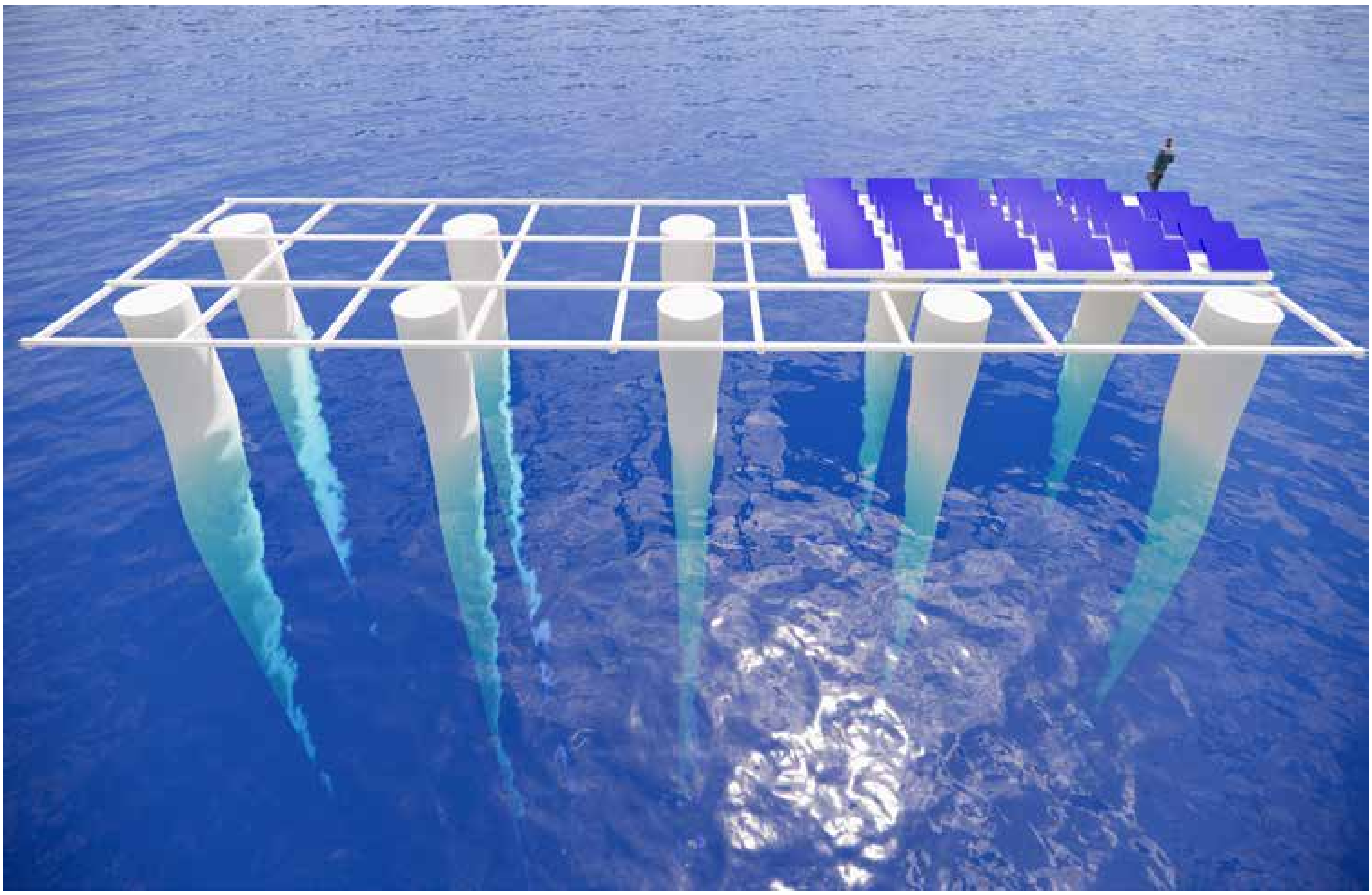


The image above shows a PV platform with 46.7m blades extending vertically downwards. Such a configuration would only be used in very deep off-shore waters. The long blades provide additional hydrodynamic stability.

45m length - 15m width

Vertical Symmetric Full-length GE37 Blades

9 by 3 bay pultruded FRP grid for PV panels

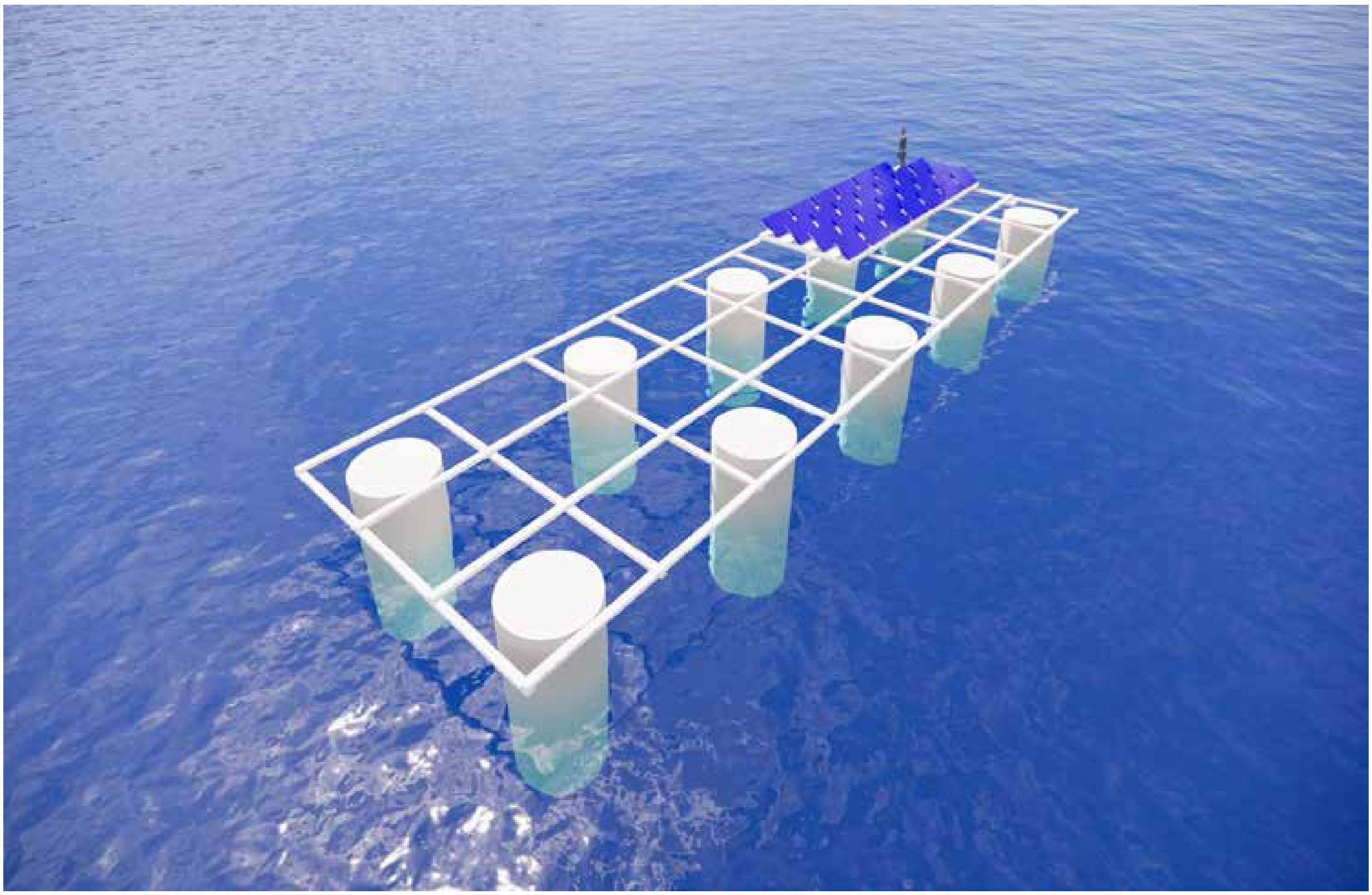


As shown above any number of blades can be used to build these platforms. Depending on the blade size, the grid dimensions change. This design shows blades in alternating bays, however, additional bays can be used to improve constructibility and buoyancy if needed.

45m x 15m x 5m depth

Vertical Symmetric Root-only C96 Blade

Total structure depth - approximately 5m

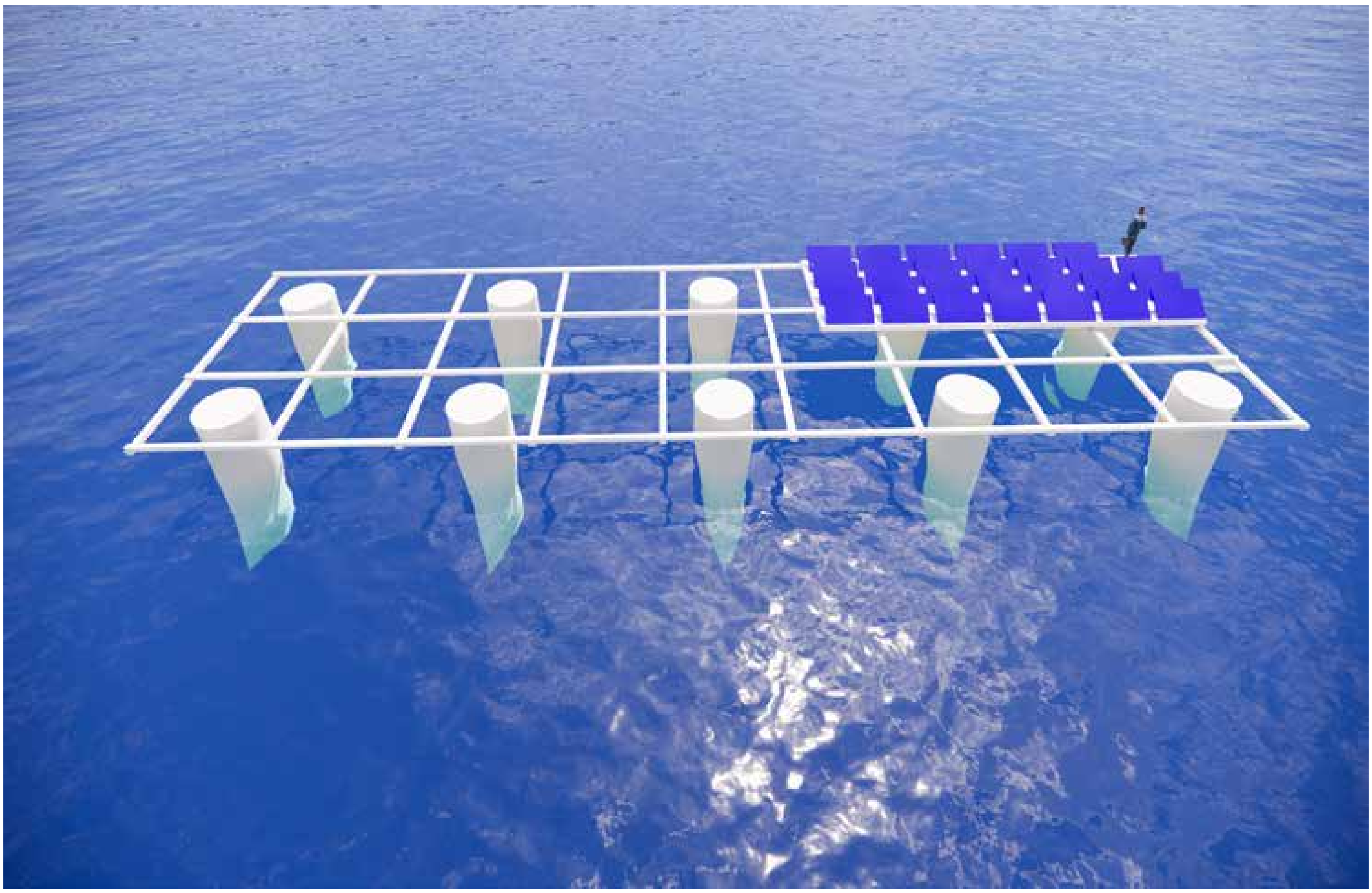


In the above configuration the C96 blades are truncated at the end of their root sections to build a shallower floating platform or to be fixed to the sea floor on a foundation system. In the floating configuration additional root sections are likely to been needed to provide sufficient buoyancy (not shown).

45m x 15m x depth

Vertical Symmetric Root/transition GE37 Blade

Total structure depth is variable



In the case of the GE37 blade which has a very short and smaller diameter root section the blade is truncated at the end of the transition region to enable greater depth to be achieved. As with the C96 version shown previously, buoyancy calculations are needed to determine the free-board height based on the number of blade sections used and payload weight.

BladeJetty

Jetties and piers, also known as, groynes, are vertical walls or barriers that extend from the sea shore (beach) into the sea. They are used throughout the world to prevent erosion of beach sand due to waves, tides and currents.

Most wall type jetties have traditionally been constructed using wooden posts and beams. They may also have sections made of concrete as seen in the image below. These materials are prone to deterioration and degradation in the marine environment.

Concrete & wooden Groyne, Pett Levels cc-by-sa/2.0 - © N Chadwick - geograph.org.uk/p/1503224

49m length

Full-length C96 Blade

Root end in the ocean

The image above shows how a wind blade could be used as a groyne in place of the traditional wooden or concrete structures. The blade could be ballasted by filling with rubble or anchored to the ground to prevent movement.

BladeBuoy

Buoys and floats are designed to float on the surface of a body of water, or are supported below the water's surface to mark a location. They are used in marine navigation, boat mooring, nautical communications, and weather observation applications. Buoys and floats were made traditionally from iron, but are now available in plastic materials such as polyethylene. Products that can be fitted with marine lanterns may carry specifications such as lantern focal height. Buoy shape, size, height, color, configuration, and markings are additional parameters to consider. Profiling buoys and floats that measure buoyancy, temperature and salinity are also available. Navigation buoys are used in harbors, bays, channels, rivers, and inland waterways to designate speed and direction (www.globalspec.com).

The root sections of wind blades are thick solid cylindrical sections typically ranging from 1 to 3 m in length, 1 to 2 m in diameter and 75 to 150 mm in wall thickness. They account for much of the composite material mass in the blade. The ends can be capped with a composite hand layup or molded cap and integrated with the above-board structure as shown in the rendering. Besides their durability in the marine environment their significant wall thickness makes them highly impact resistant and damage tolerant - additional key design criteria for buoys.

BladeBridges

BladeBridges are pedestrian, cycle and vehicle bridges that use wind turbine blades as their primary load-carrying structural members.

BladeBridges are shown for 5m, 6m, 12m, 15m, 23 m long span lengths and for 3m, 4m and 6m deck widths. Blade type and length depends on the BladeBridge span length. Designs are presented for all four blade models - N29, V44, GE37 and C96.

The wind turbine blades are typically placed on the sides or underneath the bridge deck. Conventional steel, timber or Fiber Reinforced Polymer (FRP) composite floor beams and stringers are connected to the blades using proprietary connectors.
The bridge deck may be timber plank, cast-in-place concrete, precast concrete panel, steel grid, steel panel, FRP panel, or any proprietary decking system. Typical steel, timber or FRP parapet and handrail systems are used. Concrete abutments with specially designed cavities are used to support the bridge ends.

Re-Wind BladeBridges have been designed to be mass-market highly-economical replacements for traditional steel, concrete and timber short-span bridges for pedestrians and cyclists. BladeBridges can also be designed to carry vehicular traffic. BladeBridges are durable, sustainable, and have a unique aesthetic.

Two-Girder Bridges

Two-girder BladeBridges are bridges that are supported by two wind turbine blades along their sides. They are typically single span bridges, but may also designed for continuous spans or for multiple adjoining simple spans.

Two-girder blades bridges are the simplest to design, construct, and make ready replacements for conventional concrete, steel or timber girder bridges. BladeBridges can be designed to have sufficient strength and stiffness to support decks of up to 6m wide and loaded with standard vehicles.

Two-girder BladeBridges may have their wind blades facing in the same direction (called symmetric) or in opposite directions (called asymmetric). BladeBridges typically span two-thirds (or less) of the original blade's length. Where the span is shorter than the blade length the tip of the blade can be extended along the ground for aesthetic or security purposes.

Two BladeBridges were designed and constructed by the Re-Wind Network in 2022. In January 2022 a 5m long by 3m wide two-girder BladeBridge with extended-tips was constructed on a greenway between Midleton and Youghal in County Cork, Ireland, and in May 2022 a 6 m long by 2 m wide two-girder experimental test bridge was constructed in a quarry in Draperstown, Northern Ireland, UK.

5m length – 3m width

Symmetric Girders - 13.4m N29 blade

Full blades - Extended tips for aesthetics

The wind blade tips can be extended into the landscape to emphasize the elegance of the original blade so the public can appreciate the environmental significance of repurposing blades. This configuration was selected by the client for the Cork BladeBridge Project.

Cork, Ireland BladeBridge

Symmetric Girders - 13.4m N29 blade - extended tips

BladeBridge on the Midleton to Youghal Greenway in County Cork Ireland

In January 2022 a 5m long by 3m wide two-girder BladeBridge with extended-tips was constructed on a greenway between Midleton and Youghal in County Cork, Ireland. The picture above shows members of the Re-Wind team at the site prior to the handrail installation and the bridge opening for traffic.

5m length – 3m width

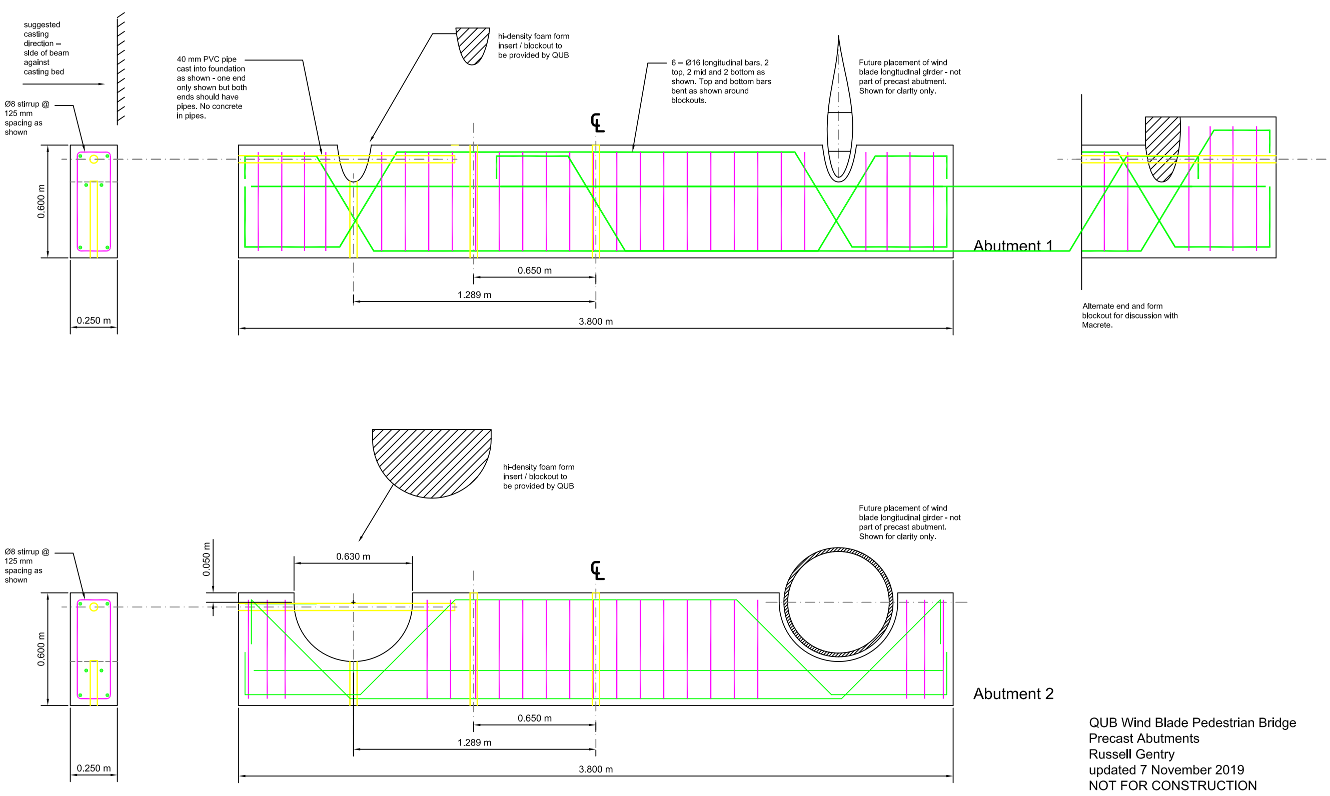
Symmetric Girders - 13.4m N29 blade

Root ends - Integrated or exterior handrail

In the image above the blade root (the circular end section that attaches the blade to the turbine hub) is shown at the left abutment. The blade profile then increases to its maximum depth near the bridge center and decreases thereafter. The cross-section changes from circular to oval to an airfoil shape along its length.

Rendering of the BladeBridge with an exterior handrail

Perspective view of BladeBridge with integrated handrail



Typical reinforced concrete abutment details for the two-girder BladeBridge

Draperstown, UK BladeBridge

Symmetric Girders - 13.4m N29 blade

Experimental BladeBridge in Draperstown, Northern Ireland,

In May 2022 a 6m long by 2m wide two-girder experimental test bridge was constructed in a quarry in Draperstown, Northern Ireland, UK. The bridge was assembled in three days by a crew of three. The bridge will be tested to failure in the summer of 2023. The picture above shows members of the Re-Wind Network on a site visit.

5m length - 3m width

Asymmetric Girders - 13.4m N29 blade

Full blades - Extended tips for aesthetics

The two side girders can be placed asymmetrically with their root ends on opposite sides of the BladeBridge span. This asymmetric configuration with the tips extended into the landscape also adds an aesthetic appeal. Since the blades both twist and bend along their length the asymmetric configuration is more complicated from a structural engineering design perspective.

6m length - 3m width

Symmetric Girders - 21m V44 blade

Root ends - Interior handrail

Longer BladeBridges are constructed with larger and longer blades. As the blade size increase so do the abutments and the gaps between the deck and the blade surface which must be accounted for in the design. The size of the blade needs to be matched to the bridge size so as not to be visually overwhelming. In the image above the V44 blade may be too large for the span and width and is better suited to a longer span.

12m length – 3m width

Symmetric Girders - 21m V44 blade

Root ends - Interior handrail

Here the V44 blade is used for a 12m long BladeBridge. The first 2/3 of the blade length in its edgewise orientation are used as the load carrying flexural element. If the tips are not extended for aesthetic reasons then other repurposing applications are needed for the remaining 1/3 of the length extending to the blade tip. A number of alternatives are shown in what follows. In this design the interior handrail is not attached to the blade but is attached to the bridge deck.

12m length – 3m width

Symmetric Girders - 21m V44 blade

Root ends - Decorated blades - interior handrail

The wind blades have large solid exterior surfaces. Wind blades are painted white to reflect light and reduce heat on the components to increase their durability (similar to fiberglass boats). In urban environments the white exterior may be undesirable. BladeBridges can be painted any color and decorated in any fashion. They can also be coated with anti-graffiti coatings.

12m length – 3m width

Asymmetric Girders - 21m V44 blade

Root ends - Interior handrail

The image above shows a 12m long pedestrian bridge with the girders placed asymmetrically. The asymmetric configuration also creates less of a tunneling effect since the large root and transition regions of the blade are not on the same side of the span. This may be desirable for larger blades on longer spans.

15m length - 6m width

Symmetric Girders - 21m V44 blade

Root ends - Interior handrail - end features

As shown above the blade ends can be used in the surroundings of the BladeBridge to build signboards, benches and to demarcate bike parking areas.

15m length – 6m width

Symmetric Girders - 21m V44 blade

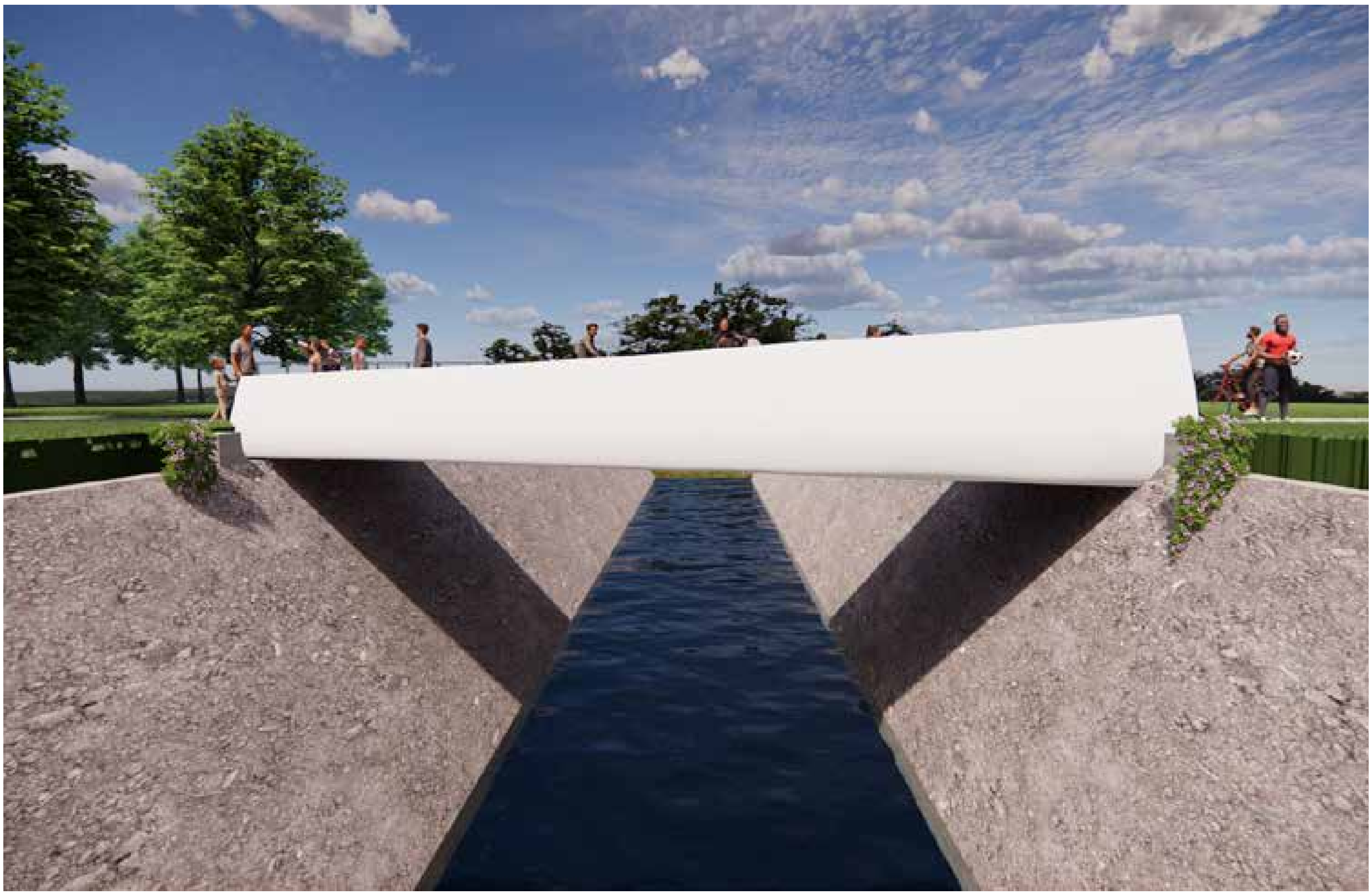
Full blades - Extended tips for aesthetics

Extended tips are shown above for a 15m long BladeBridge. As can be seen the tip end becomes very shallow and due to the blade twist and curvature it splays outward from the path. This demonstrates the importance of developing a high fidelity geometric blade model for actual architectural design purposes. Generic sketches of wind blades cannot be used for anything more than early brainstorming exercises and perhaps for conceptual design.

15m length – 6m width

Symmetric Girders - 37m GE blade

Mid-section of blade - Interior handrail

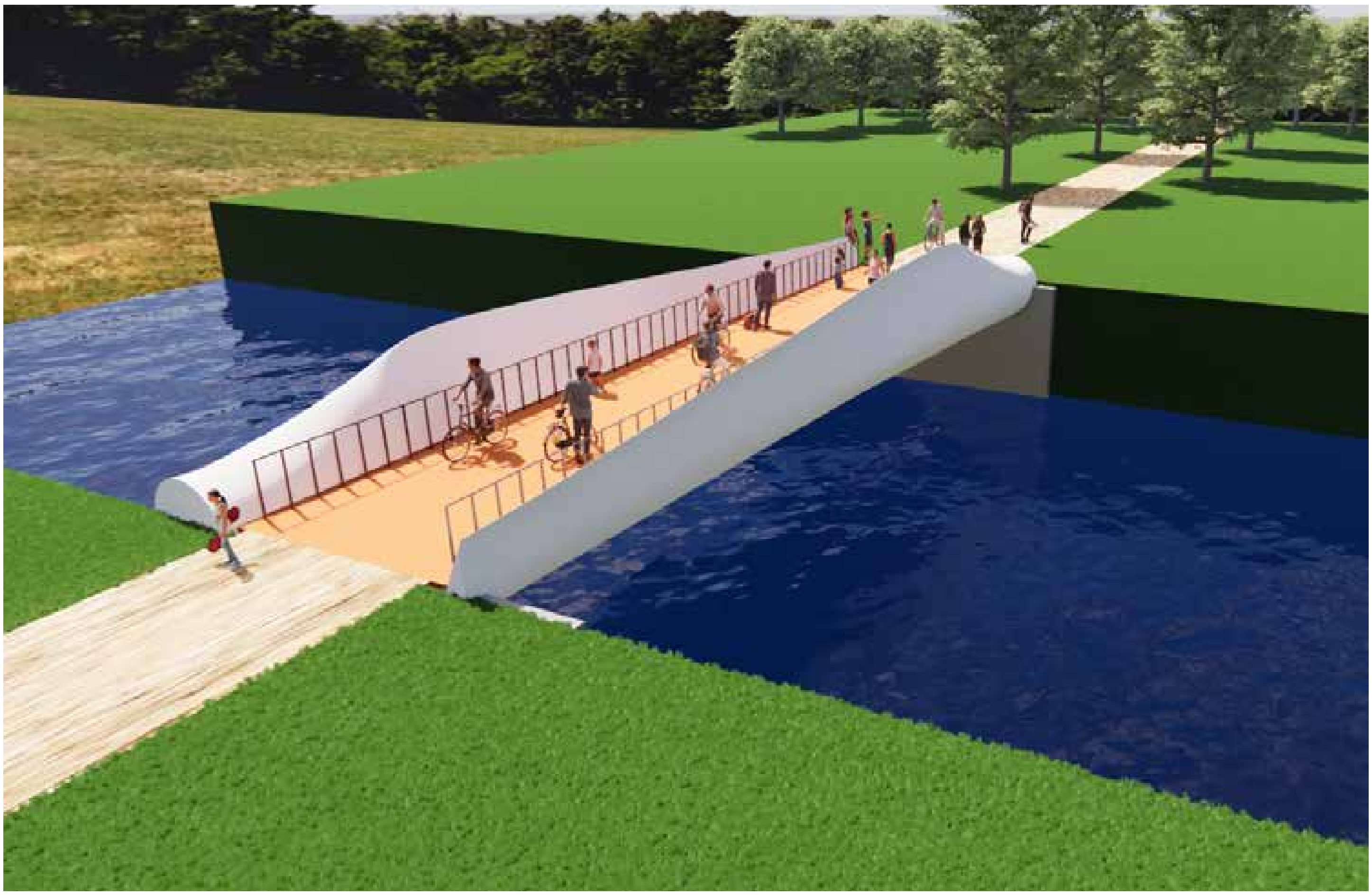


It may be preferable to use the middle section of a blade and not start from the root end as has been shown in the previous renderings. A part of a 37m long blade is shown here spanning only 15m. As can be seen the depth at the shallow (tip) end is still substantial. In fact the blade may have to be lowered on the abutments so as to allow pedestrians to see over the edge at the deep end.

23m length - 3m width

Asymmetric Girders - 37m GE Blade

Root ends - Interior handrail



Much longer spans can be constructed using larger blades. Asymmetric configurations are preferred for the longer spans and bigger blades primarily for the aesthetics and the depth of the blade. As can be seen in the rendering above the blade at the transition region could well be taller than an adult pedestrian or cyclist. This is probably undesirable, unless the intention is to hide the outside surroundings or provide protection from the wind.

23m length – 6m width

Symmetric Girders - 37m GE blade

Full blades - Extended tips for aesthetics

A 23m long BladeBridge with extended tips is shown in the rendering above. The extended tips can also provide some additional protection in the bridge approach area. A 6m width can be achieved with these large blade girders.

32m length - 6m width

Symmetric Girders - 46.7m C96 blade

Root ends - interior and middle handrails

The final two-girder BladeBridge image shows a 32m long by 6m bridge with two opposing lanes of traffic. This is often desirable on cycling paths. The very large size of the blade root at the abutment is seen in this case. The geometric taper in the width and the height becomes much more apparent at this scale.

Single-Girder Bridges

A single wind blade can be used to construct a BladeBridge with the bridge deck cantilevered off of one or both sides of the blade.

Due to the high torsional stiffness of the multi-cellular wind blade it can be used to support a deck that is cantilevered off only one side which allows for a novel structural system. The cantilevered deck system can be attached at the height of the blade spar cap using a variety of connector types.

Using a single blade for a pedestrian bridge that carries modest loads is especially economical as a foundation system for only one blade is needed on either side of the span. The blade can be embedded in the ground as shown in the image on the previous page or a cast-in-place foundation can be used to prevent torsional rotation of the blade at its ends.

When a single blade is used to support a deck cantilevered on both sides of the blade the torsional stiffness of the blade is also beneficial as the design must include the load case of live load on only one side of bridge. However, the dead load of the deck on either side of the girder creates a balanced gravity load so the torsional load is not at large as with a single side deck.

15m length - 2m width

Single blade - 45m B45 SGRE Blade

Mid-section of one blade

The image above shows a side view of the single-blade BladeBridge. 15m of the mid-section of a Siemens B45 wind blade was used in this rendering. The one-sided deck is cantilevered off the blade and supported by steel brackets that extend under the deck (like bridge deck formwork overhang brackets).

Multi-Girder Bridges

Wind blades can be used to construct BladeBridges that are wider than those that can be supported by two girders on either side. Bridge superstructures of this design are common in vehicular bridges or wide pedestrian bridges and are typically constructed using precast concrete, steel or glulam timber girders placed under the bridge deck.

In multi-girder BladeBridges the wind blades may be oriented with either the rounded leading edge or the narrow trailing edge facing upwards to support the deck. The wind blade girders are connected to the bridge deck using specially designed connectors. The bridge deck may be of cast-in-place concrete, precast concrete panel, steel grid, steel panel, FRP panel, timber plank or any proprietary decking system. Typical steel, timber or FRP parapet and handrail systems can be used. Concrete abutments with specially designed cavities can be designed to support the bridge ends.

Multi-girder BladeBridges can be designed to carry standard highway and roadway traffic. They can be substituted for conventional steel and precast concrete girders. They are not dissimilar to other proprietary FRP girders that have been produced for this purpose. However the wind blade girders for BladeBridges come at a substantially reduced cost and weight from these custom systems.

12m length – 6m width

Symmetric Girders - 21m V44 blade

Root ends - 3 girders below deck level at 3m spacing

Three wind blades of the same type are used in the above BladeBridge to support a 6m wide pedestrian deck. The girders are mostly hidden from view in this configuration which may be desirable in certain locations. With the girders placed below the deck the pedestrians have a more expansive view of their surroundings.

Perspective shown from path

View from above

This view from below shows the blades with their leading edges facing downwards. The blade twist can be seen in the middle girder. The shadows on the left-hand girder create an interesting stripped effect.

Notes:

1. Wider bridges can be constructed using more girders.
2. Asymmetric girder directions are also possible and are preferable for multiple girders.
3. Wide multi-girder BladeBridges of this type can support conventional vehicular traffic.

Low-Profile Bridges

Wind blades can be used to construct a variety of low-profile BladeBridges for low clearance conditions or for aesthetic reasons. In this design the wind blades are sliced horizontally and placed side by side with their trailing edges abutting each other.

To achieve the required capacity in this configuration the wind blade may need to be used as a load-carrying permanent (stay-in-place) concrete form and filled with lightweight filler and concrete. This is similar to metal stay-in-place forms used in bridge deck construction. The concrete may be reinforced or unreinforced and acts as a structural composite with the wind blade which serves as the tension member of the FRP concrete composite system. A concrete deck can be cast together with the low-profile FRP concrete superstructure and also acts compositely with the FRP wind blade. A variety of handrail systems can be connected to the deck system.

16m length – 6 m width

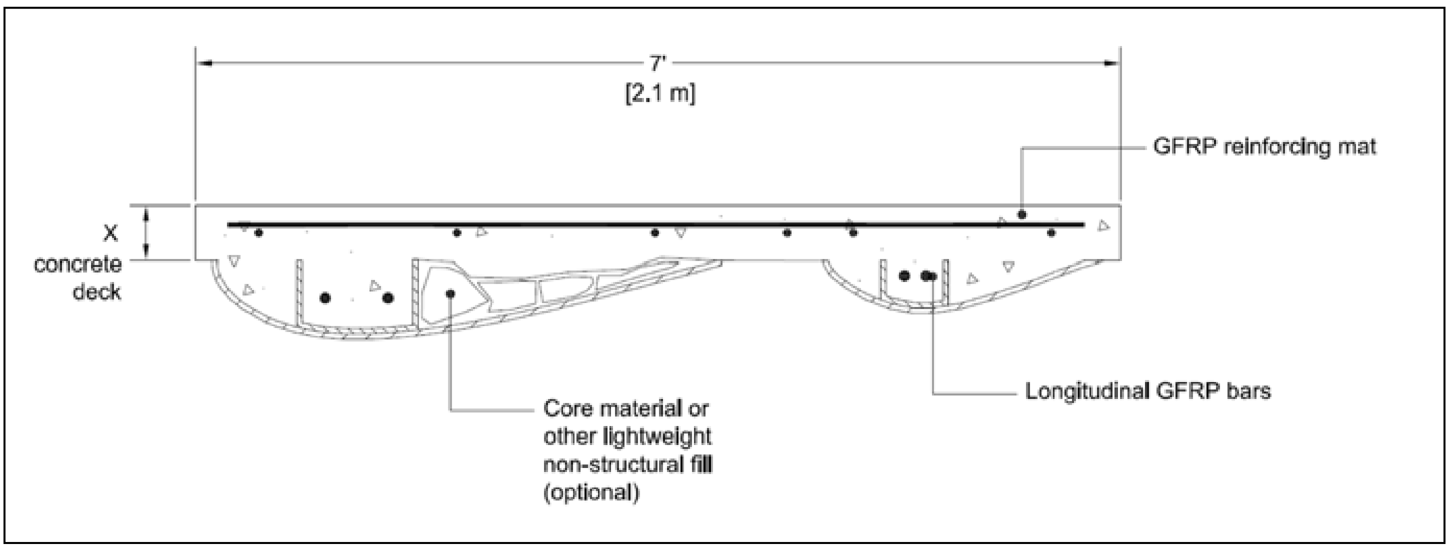
Asymmetric blades - 37m GE Blade

Mid-section of 2 blades cut edgewise

The image above shows the side view of the low-profile BladeBridge. Two mid-sections of the 37m GE blade are used in this configuration. The low-profile bridge is “hidden” from the pedestrians and cyclists above but can be seen from the side. The low profile BladeBridge is ideal for bridges with low overhead clearance. Since the root ends and the tip ends of the blade are not used in this design they can be utilized for other repurposing applications.

View from the bridge approach

View from below showing mating trailing edges of the blades



Typical cross-section of a low-profile BladeBridge

5m length – 3m width

Asymmetric blades - 21m V44 blade

Mid-section of 2 blades cut edgewise

Shorter low-profile BladeBridges can be designed using the mid-sections of smaller wind blades. The above image shows a 5m long low-profile bridge made from two V44 wind blades. As the blade size decreases so does the depth of the superstructure.

Cable-supported Bridges

A variety of cable supported BladeBridges have been considered by the Re-Wind team. These include: Cable-stayed bridges with single or double wind blade pylons and pre-tensioned angled cables, suspension bridges with wind blade pylons and catenary cables and hangers, and through-arch bridges with wind blade arches and cable hangers.

Suspension or stay cables can readily be attached to the blade spar cap and used to support a bridge deck of timber, concrete, FRP or steel. Conventional steel braided wire cables or proprietary FRP cables can be used.

The root of the wind blade makes an ideal location for attachment to a concrete foundation. The existing anchor rods in the blade root can be mated with anchor bolts extending from the foundation similar to the BladePole application shown in what follows.

23m bridge - 3m width

Symmetric Arch - 21m V44 blade

Full length of blade - suspended deck

The image above shows an arch-type BladeBridge with the wind blades serving as the primary structural members. Hanger cables extend from the blades to the sides of the bridge deck. The above configuration can also be designed using four blades - two on each side for additional load carrying capacity. The blades are attached to a concrete foundation at their bases.

BladeBoardwalks

Similar to the BladeBridge the BladeBoardwalk is used to support a pedestrian deck.

Boardwalks are needed in marshy wetland areas in parks and nature reserves where pedestrian access is desired and the flora and fauna need to be protected. Boardwalks often use timber plank decking that is compatible with the natural surroundings. However, the substructure supporting the pedestrian deck is typically also of timber construction and is susceptible to deterioration and needs regular costly maintenance and repair.

BladeBoardwalks replace the timber substructures with fiber reinforced composite wind blade beams that will require less maintenance and repair.

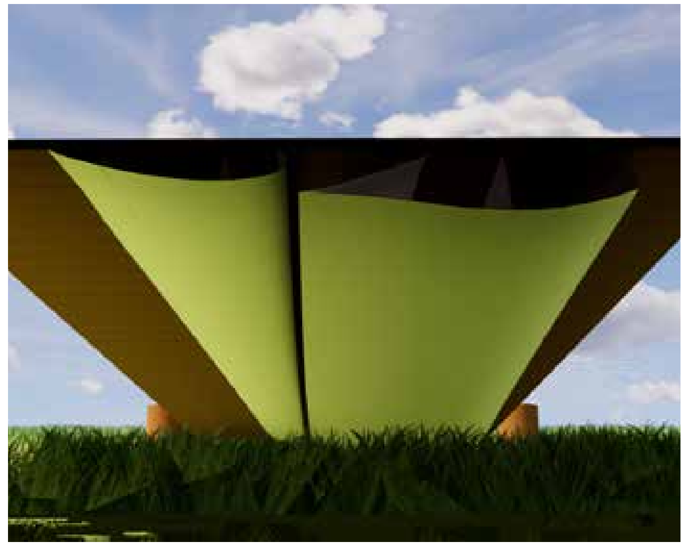
11m length - 2m width

Asymmetric forms - 13.4m N29 blade

11m of blade length - 2 blades cut edgewise

The BladeBoardwalk shown above uses the full length of the V29 blade - sliced in half - running the full length of the blade. The blade halves are placed alongside each other asymmetrically. In this design a middle support is used to create 5.5m spans. Additional support is needed since the blade is not filled with concrete (as in the low-profile BladeBridge) since the loads are less and the spans are shorter.

Typical low level boardwalk with no handrail



Section from below showing cut blade sections.

View from above the Boardwalk

Notes:
1. Boardwalk shown has timber decking.
2. Boardwalk shown has conventional timber posts and substructure beams.
3. Boardwalk shown is 2m wide. Wider boardwalks are readily accommodated.
4. Long boardwalks are constructed in a repeating pattern.
5. Many blades can be repurposed with this product.

11m length - 4m width

Asymmetric forms - 13.4m N29 blade

11m of blade length - 4 blades cut edgewise

The image above shows a 4m wide BladeBoardwalk that uses four N29 blades side-by-side as the supporting structure for the timber deck.

16m length – 6m width

Asymmetric forms - 37m GE blade

16m from middle section - 2 blades cut edgewise

BladeBoardwalks can span longer distances with larger wind blades. The above image shows the underside of a Bladeboardwalk constructed from the middle sections of two GE 37m long wind blades.

BladePoles

The Re-Wind Network BladePoles are wind blades that are repurposed to be used as poles of many different types depending on the desired product.

These include powerline poles for both distribution and transmission lines, cell phone towers and poles, lighting and luminaire poles, and sign support poles.

The type of blade used for a BladePole depends on the desired height and load carrying capacity needed.

BladePoles are embedded in the ground or attached to concrete foundations. The existing bolts or bolt cavities in the root section can be used to make connections to the foundation.

37m height

230 kV Transmission line pole - 37m GE blade

Cantilevered at root end

The image above shows a BladePole made from a full-length 37m GE wind blade configured as a 230 kV transmission line tangent pole. A prototype mock-up of this BladePole has been assembled at Georgia Tech. Demonstration BladePoles of this type will be installed in South Carolina, USA in 2023 (Georgia Tech Patent Pending).

BladePole in an arid environment

BladePole mock-up in laboratory

Multiple BladePoles in a transmission line

Notes:
1. For distribution lines carrying less than 69 kV and 10-12m high smaller blades can be used.
2. For transmission lines ranging from 138 kV to 500 kV blades of different sizes can be used.
3. BladePoles are particularly suited to angle poles and dead-end poles due to their large moment carrying capacity.
4. The existing grounding cable in the blade can be used as the pole ground.

13m, 21m and 46m height

13.4m N29, 21m V44, 46.7m C96 blades

Cell Towers - blades cantilevered at the root end

BladePoles can make attractive cell-phone towers. Larger blades can be used for tall towers in place of the “artificial trees” often used. Smaller blades, as shown in the image above, can be used in urban and suburban neighborhoods for new 5G cellphone towers. The BladePoles have the added advantage of being electromagnetically transparent which allows the communication equipment to be installed inside the blade (not shown here).

BladeBarriers

Many types of barrier structures can be designed from wind blades.

Noise BladeBarriers alleviate noise pollution and limit access alongside major highways and larger roadways in residential neighborhoods and industrial areas.

Construction BladeBarriers provide security, prevent unwanted entry, and protect construction workers and the public from harm around construction sites.

Seawall BladeBarriers serve to protect coastlines and prevent erosion of sand and topsoil. They may also serve as protective barriers against future sea-level rise.

Wind-attenuating BladeBarriers serve to protect property from high winds. Coastal wave-attenuating BladeBarriers serve to reduce waves and limit beach erosion. Groyne or jetty BladeBarriers can also be used to prevent sediment erosion and beaches washing away.

Noise Barrier - 6m high

Vertical full sections - N29 or V44 blades

Regular or irregular geometries

In this design multiple sections cut from blades are arranged in regular or irregular patterns to create the BladeBarrier. The image above shows large and small sections of a 21m V44 blade arranged in a repeating though irregular pattern to create a variegated wall.

Regular pattern - N29 blades

Irregular pattern - V44 blades

BladeBarrier from 13.4m N29 blades arranged in a regular repeated pattern around a construction site

Notes:

1. Designs shown can also be used for wave and wind attenuating and sea-wall barriers.
2. Barrier heights can be varied based on blade size and design requirements.
3. Many wind blades can be used in this application.

Noise Barriers - 4m high

Vertical sections - 46.7m C96 blade

Irregular geometries

Arc-shaped segments cut from the shell of a large wind blade can be installed vertically to create a continuous wall system for both highway barriers and for construction site barriers (aka hoardings).

Noise Barriers – 6m high

Horizontal sections - 46.7m C96 blade

Irregular geometries

In this design the long 46.7m blades are sliced lengthwise and split open. The webs are removed and the long blade sections are stacked to create the 6m high "wall." Vegetation grows through the gaps in the blade and over the top to provide a natural looking barrier.

Noise Barrier - 4m high

Sections of 13.4m N29 blade as posts

Regular spacing - used with slide-in infill panel

Sections of the blade spar-cap can be extracted to make stiff vertical posts to replace timber or steel posts currently used to make construction barriers. They can be reused multiple times. Conventional plywood or composite infill panels can be used with this design.

BladeShelters

A variety of shelters, canopies and roofing products can be made from blade parts. These include bus-stop shelters, bicycle storage shelters, building entry canopies and parking-lot canopies.

A variety of construction material products can be made from pieces and parts of the blade. Depending on the size of the blade segment it can be used as an entire roof system for a 40 square-meter affordable house or as a bus or bike shelter. Or, it can be cut into arc shaped planks for roofing. The image on the previous page shows housing parts made from the SANDIA 100m long wind blade model.

Blades can also be used to build glamping pods. These small shelters can utilize different sized blades and be constructed in may different configurations. Glamping (or Glamorous Camping) is becoming popular in Europe and the US. Weatherproofing and warmth are essential in a glamping pod. Wind blades can serves as a roof or wall, thereby replacing the requirement for roof trusses and sheet metal. The blades are more durable and have a longer design life than wooden trusses or sheet metal. Wind blades can be used elsewhere in a glamping pod campground as large tents or shelters for communal gathering.

Bus shelter - 3m wide

Roof, benches and planters - 13.4m N29 blade

Mid-section for roof; root section for benches

A bus shelter made from clearly recognizable sections of a wind blade can be an iconic choice for a civic structure. The shape of a wind blade can allow water to naturally run off, and the material is durable with a long design life. Bus shelters are typically made from polycarbonate material, which needs to be replaced approximately every 10 years.

Bus shelter roof from above

Approaching the bus shelter

Blade root sections for benches and planters

A-Frame Glamping Pod

Walls and foundation - 21 m V44 blade

Root section foundations for platform

The image above shows a small 2.7m wide A-frame glamping pod. Sections of the shell of a V44 blade are embedded in the ground at an angle. A cap beam is made from the internal spar-box of the blade. The blade root is used to support the floor. It is envisioned that farmers may wish to build “Do-it-Yourself” (DIY) glamping pods using blades from decommissioned wind farms in their local region or on their own property. Re-Wind can supply plans and construction details. Designs will depend on the actual blades available.

A-Frame Glamping Pod

Walls - 13.4m N29 blades

Root section foundations for platform

The image above shows a 5.13m wide glamping pod. In this design multiple small N29 blades are used to create the wider A-frame. The glamping pods shown do not have end closures which are required. Various options are possible for the ends.

BladeFarming

Wind farms are often built on conventional farms. Using the blades on the farm decreases the cost of transporting the decommissioned blades.

Many different BladeFarming everyday products and storage structures can be built using blade parts. The blades can be used in barns and in fields to create cattle partitions, grain storage partitions, and feed bunks of different types. Root sections can be used as tanks and tips can be used as fences as in the BladeBarrier application.

Similar to the BladeShelter glamping pods, it is envisioned that farmers may wish to build “Do-it-Yourself“(DIY) farming structures using blades from decommissioned wind farms in their local region or on their own property. Re-Wind can supply plans and construction details. Designs will depend on the actual blades available.

Cattle Partitions

14.3m N29 or 21m V44

2-3m long blade tips are bolted to the stall wall.

Cattle partitions serve to separate and protect cows while resting, define their place for lying, and guide them when entering or exiting a stall. Partitions made from wind blade tips can be bolted horizontally to an existing frame, and would be weatherproof and durable.

Grain Partitions

14.3m N29 or 21m V44 blade mid-section

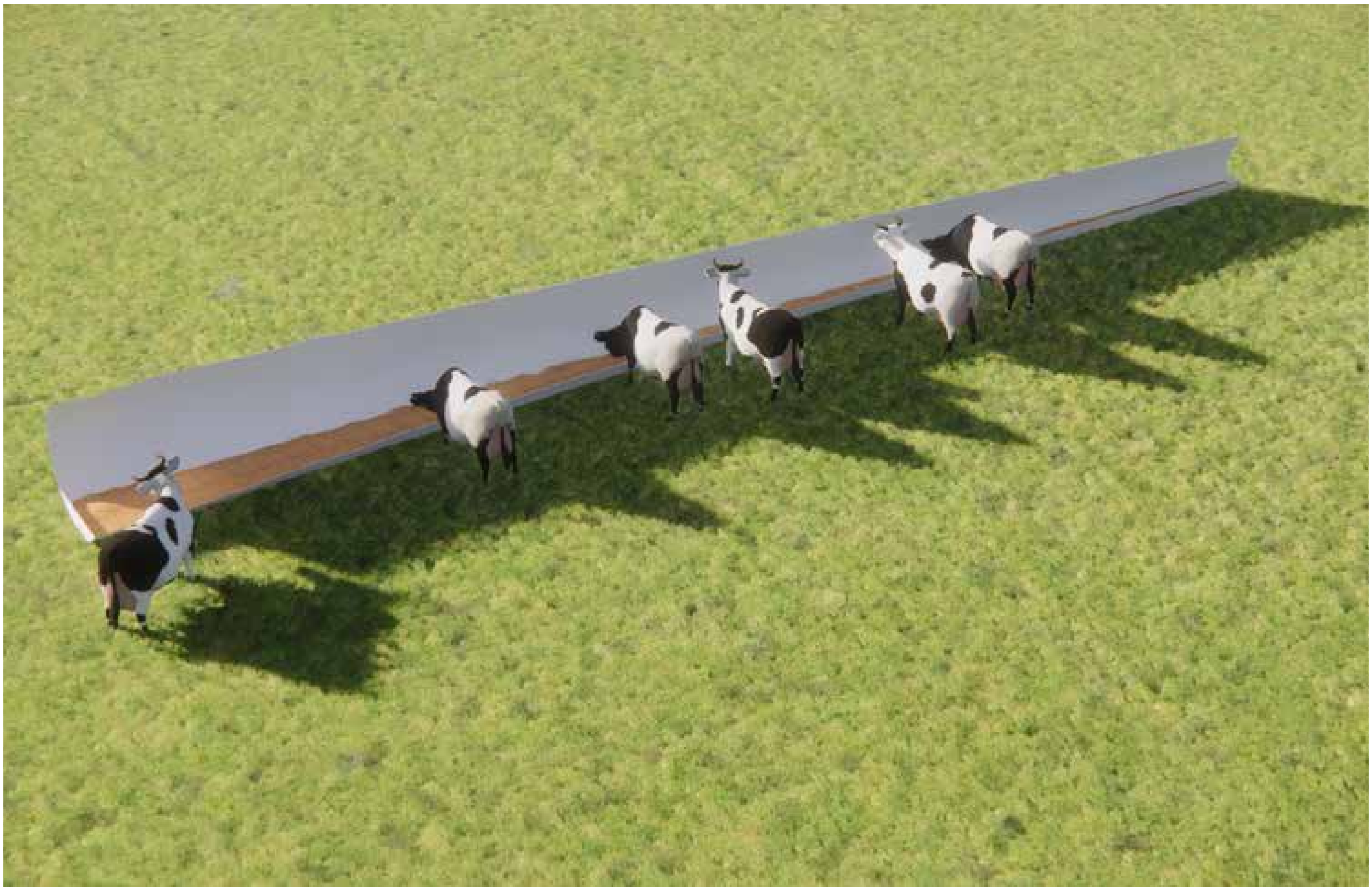
3-4 m long mid-section of the blade - leading edge cavity removed.

Grain partitions from wind blades can be bolted horizontally to a steel frame, and filled with on-site rubble in order to create a ballast. They are lightweight when un-ballasted, making them easy to move. The glass fiber material is extremely durable and weather resistant.

Feed Bunks

37m GE blade

Variable length depending on local conditions.



The image above shows a feed bunk (or trough) cut from a section of the shell of 37m blade. The feed bunk sown above is 17m long making it easily transportable on a standard flatbed truck. The BladeBunk is light-weight and very durable and a potential replacement for heavy reinforced concrete existing feed bunks. The bunks can be designed in many different lengths with many different blade types. They can also be used as water troughs.

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