Wave Catcher Barge© Presentation

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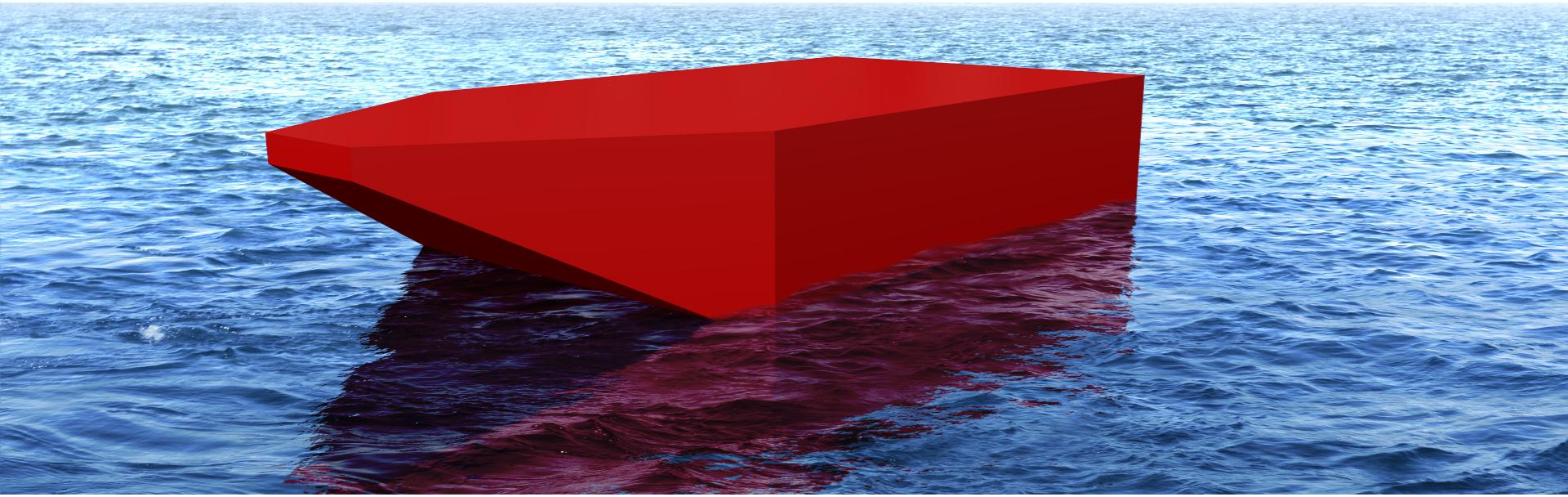
February 4, 2015

Wave Catcher Barge© With Transparent Top Enclosure

Wave Catcher Barge© Uses Its Mooring System To Turn Wind Turbine Type Generators Located Inside A Water Tight Enclosure On Top Of The Barge

Wave Catcher Barge©



The Wave Catcher Barge© Bow Is Designed Direct Very Large Waves To the Side Of The Barge And To Direct Normal Waves Under The Barge To Lift Barge.

US Patent 8,823,196 B1 – The Wave Catcher Barge

US008823196B1

(12) **United States Patent**
Gehring

(10) **Patent No.: US 8,823,196 B1**
(45) **Date of Patent: Sep. 2, 2014**

(54) **APPARATUS OF WAVE GENERATORS AND A MOORING SYSTEM TO GENERATE ELECTRICITY**

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(72) Inventor: **Donald H Gehring**, Houston, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/249,910**

(22) Filed: **Apr. 10, 2014**

Related U.S. Application Data

(60) Provisional application No. 61/862,338, filed on Aug. 5, 2013.

(51) **Int. Cl.**
H02P 9/04 (2006.01)

(52) **U.S. Cl.**
USPC **290/53**; 290/42

(58) **Field of Classification Search**
USPC 290/42, 43, 53, 54
See application file for complete search history.

(56) **References Cited**

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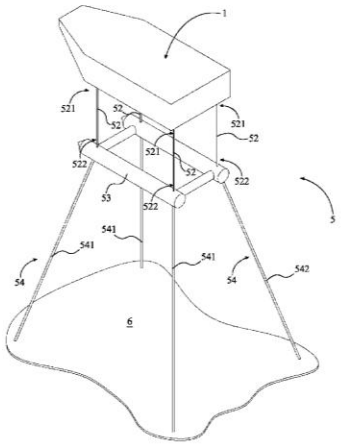
Primary Examiner — Nicholas Ponomarenko

(57) **ABSTRACT**

An apparatus of wave generators and a mooring system is used to generate electricity includes a floating hull and an anti-drift mooring system. The floating hull that functions as the floating member is tensionably coupled with a subsurface environment by the anti-drift mooring system, where the anti-drift mooring system can include different embodiments depending on the subsurface environment. Articulated pulley systems of the floating hull allow the anti-drift mooring system to efficiently maximize the power output of wave generator units of the floating hull as the articulated pulley systems and the wave generator units are positioned within the floating hull.

16 Claims, 23 Drawing Sheets



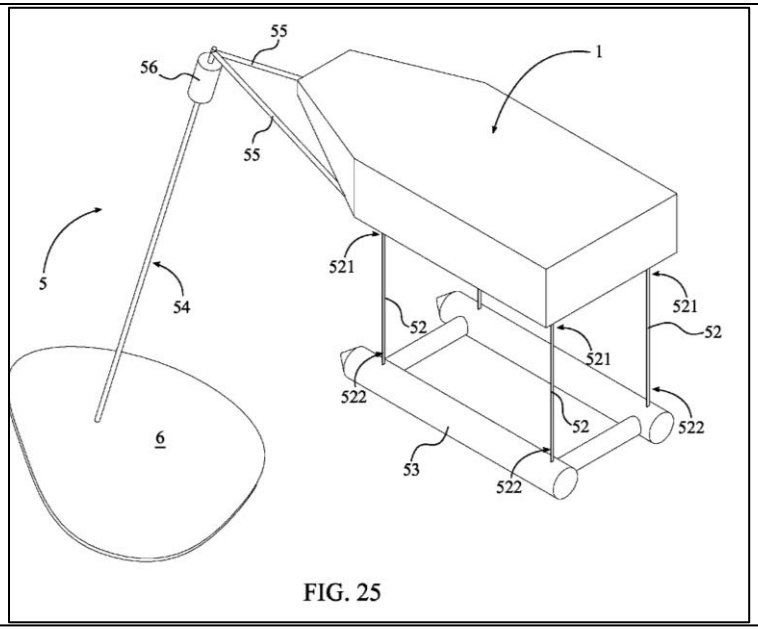


FIG. 25

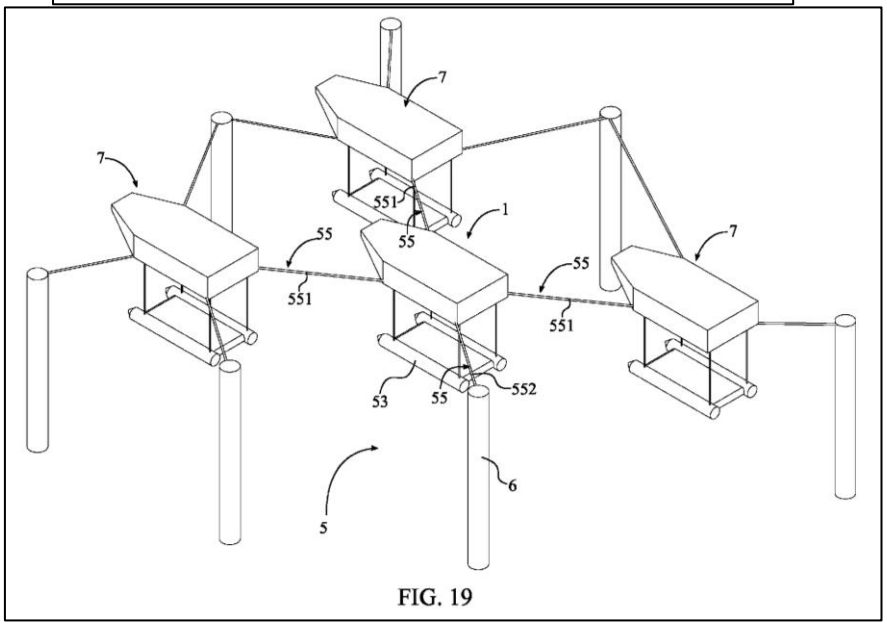
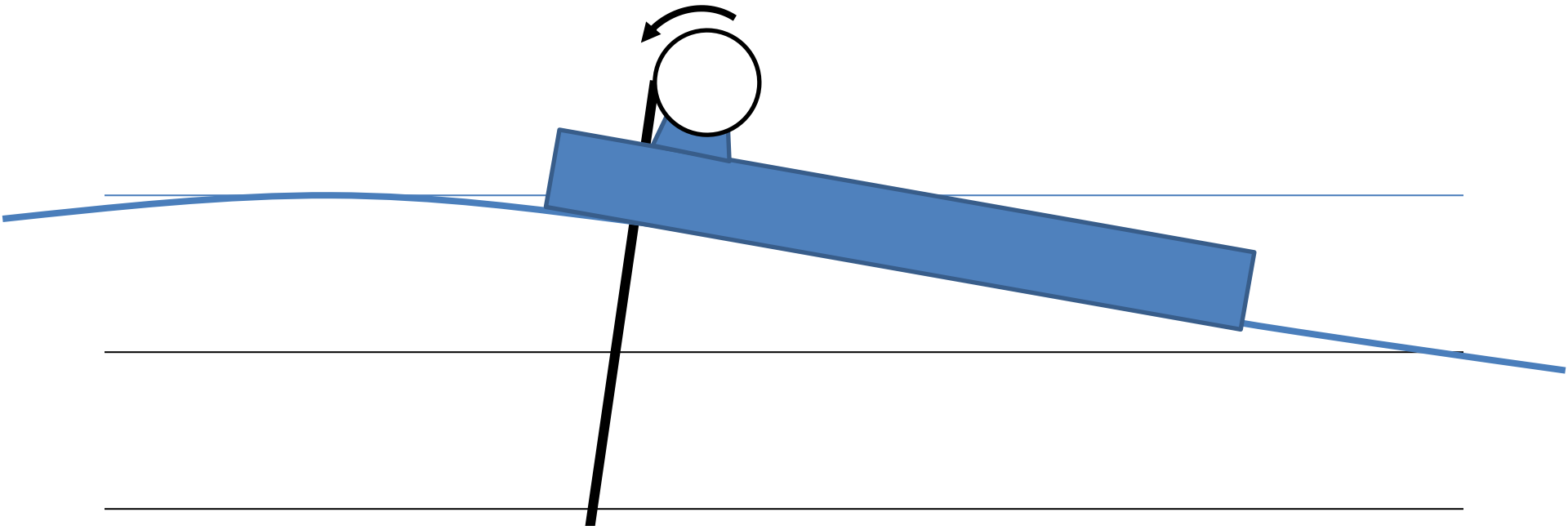


FIG. 19

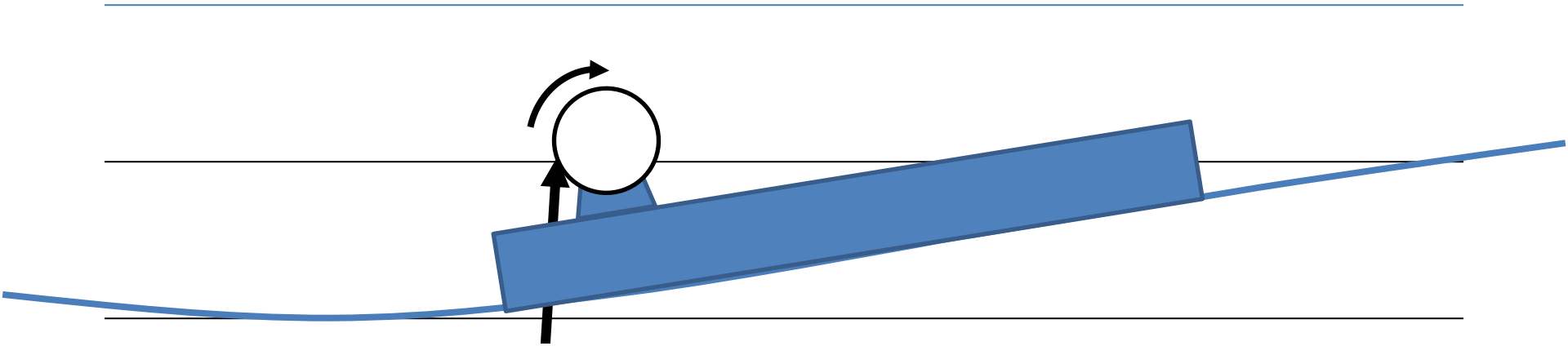
The Patent Has Also Been Filed In China, Taiwan, Korea and Japan.

The Stricklin Tide Supply Vessel Rolling In Swells Waves Offshore Angola

STRICKLIN TIDE
Offshore Supply Ship
IMO: **9422926**
MMSI: **576472000**
Call Sign: **YJVM7**
Flag: **Vanuatu (VU)**
AIS Type: **Other**
Gross Tonnage: **1713**
Deadweight: **1816 t**
Length × Breadth: **60m × 16m**
Year Built: **2009**
Status: **Active**

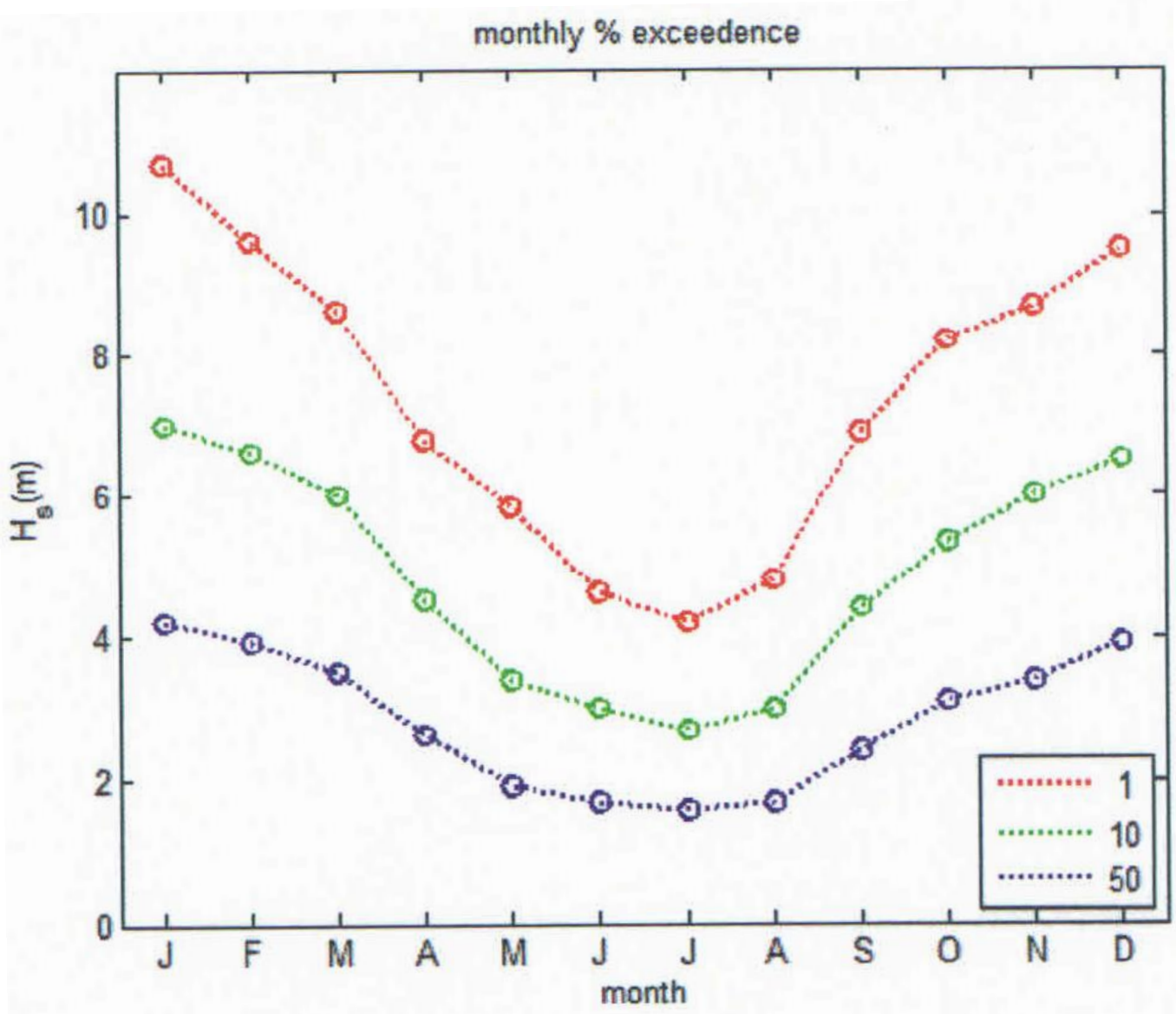


When the barge is lifted up by the wave crests, the mooring lines pull down and turn the pulleys, flywheels and generators on the barge.



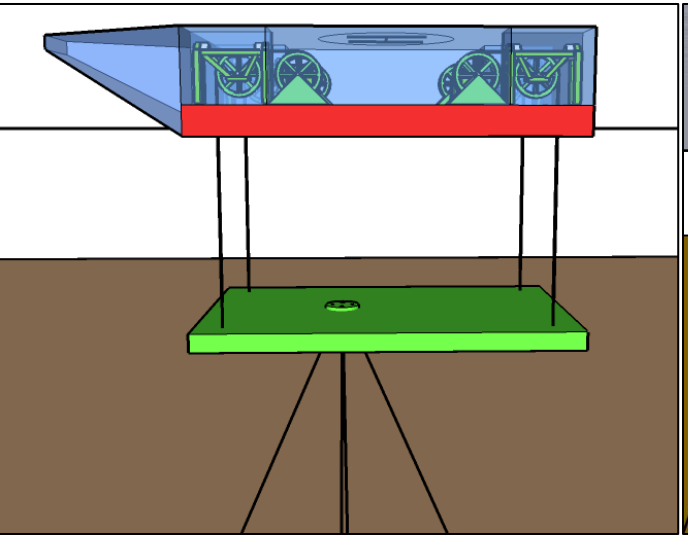
When the wave trough lowers the barge, the uni-directional pulley recoil springs rewind mooring lines back on the pulleys keeping mooring lines tight at all times.

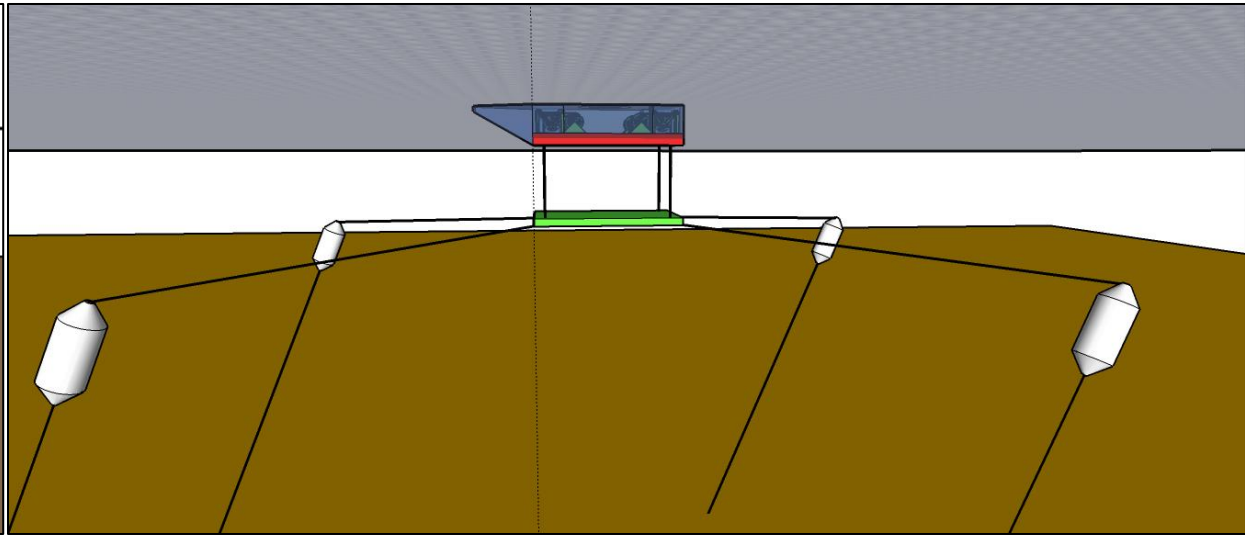
Typical Monthly Wave Height Exceedence

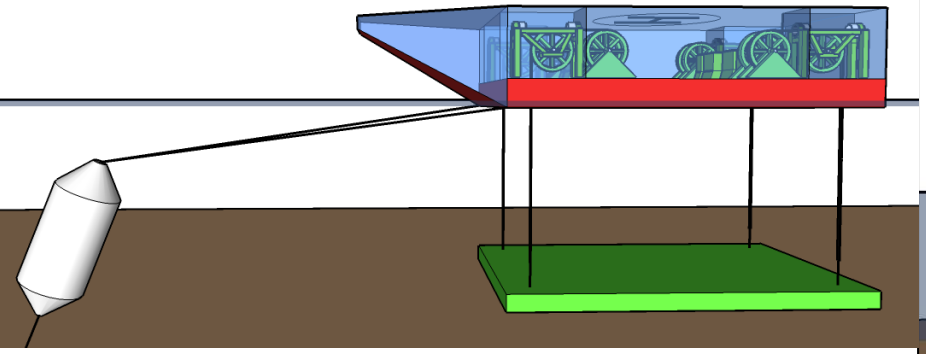


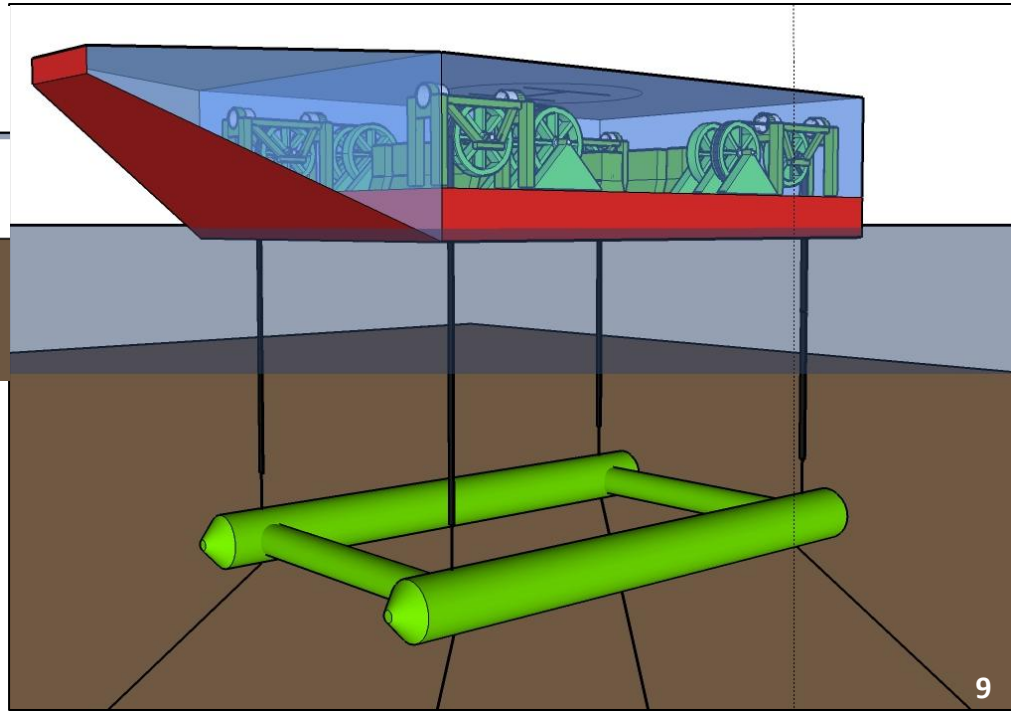
Example Monthly % non-exceedence of H_s

Wave Catcher Barge© Mooring Systems

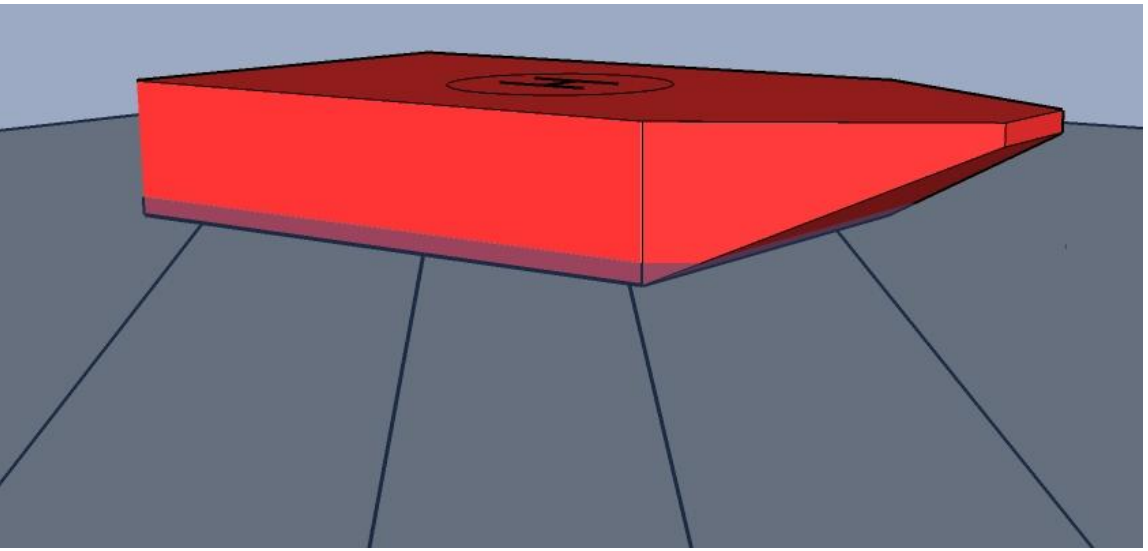


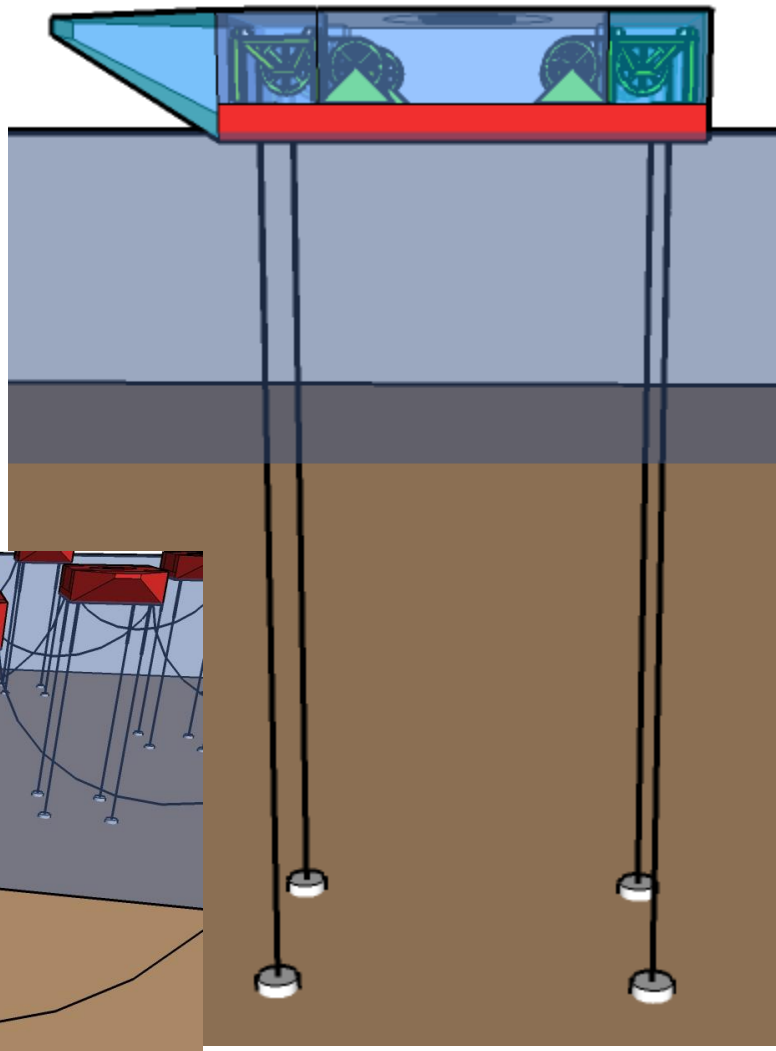


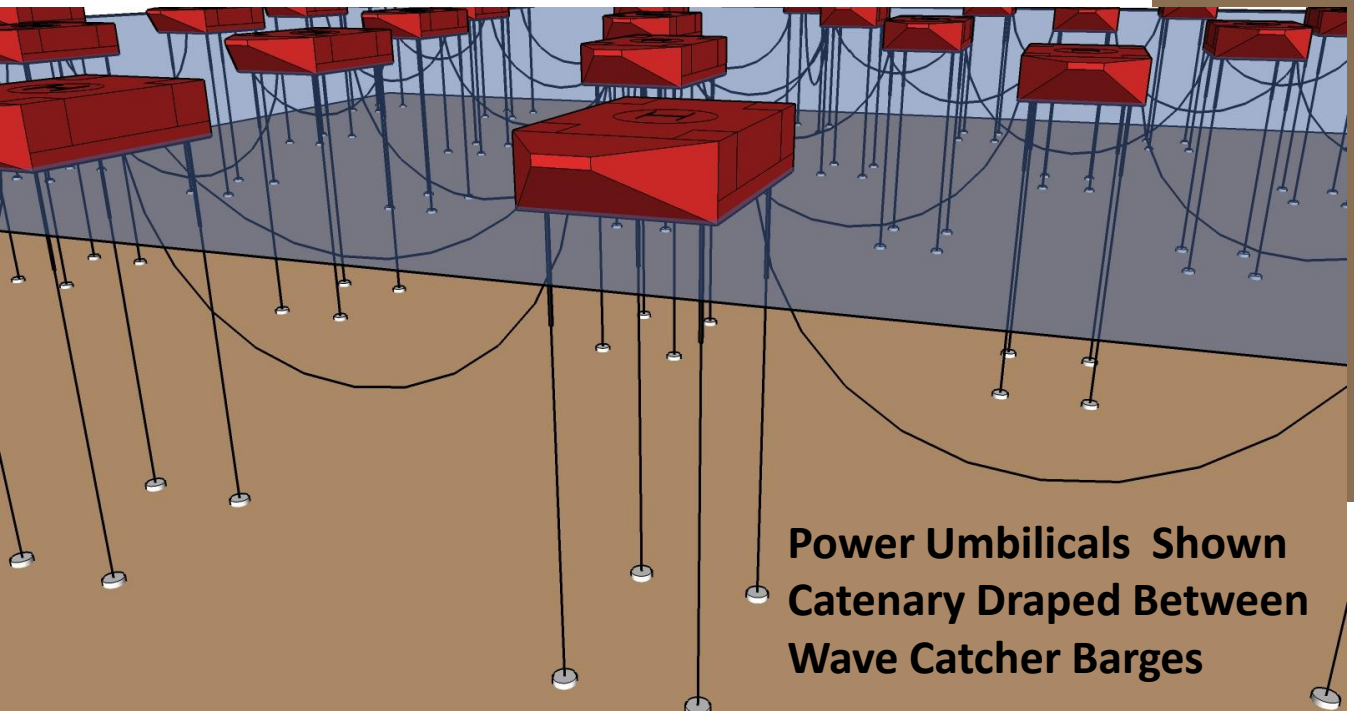




Wave Catcher Barge© Mooring Systems







Power Umbilicals Shown
Catenary Draped Between
Wave Catcher Barges

Wave Catcher Barge© Description and Principles

4 or more wind turbine type generators located inside a water tight enclosure on top of a barge. The barge is moored directly to the seabed or to an intermediate subsurface structure with 4 or more mooring legs or is allowed to weathervane into the waves. The hull's vertical belt mooring legs turn the generators.

The small light weight barge is very responsive to normal open ocean waves. The hull's low drag coefficient bow minimizing horizontal loads on the hull while the hull's flat bottom maximize vertical loads on the hull. In the open ocean, the largest energy is the vertical lift force of the waves and that is what this hull design captures. The barge's mooring system can either fix the bow heading of the barge into the direction of the prevailing waves or free the barge to weathervane about its bow mooring. The offshore business commonly uses both types of moorings.

The hull can be moored in shallow water to ultra deep water. In deep water, the hull can be moored to a buoyant pre-installed intermediate structure offering the advantages of fast surface mooring connections and disconnections and near vertical upper mooring legs. The hull can also be moored to a spring buoy single point mooring system which also allows fast connection and disconnection and the additional advantage of weathervaning which minimizes mooring loads.

Wave Catcher Barge© Description and Principles
(Continued)

Both the submerged structure and the spring buoy can be pre-installed allowing the hull to be quickly connected or disconnected. The submerged buoyant frame can be towed to site, connected to its moorings and submerged to its design depth using controlled ballasting. The spring buoy mooring system can also be towed to site and preinstalled to its foundation anchor. The spring buoy, when on its own, will extend above the water's surface for easy surface connection and disconnection. The weathervaning hull option uses a counterweight sea anchor suspended by the vertical mooring legs to maintain the mooring legs in a vertical orientation while providing and a vertical mooring leg anchor. The sea anchor will be located at a depth that is not influenced by normal wave loading but at a depth that allows the sea anchor to move with the hull under major storm wave conditions limiting the loads on the vertical mooring legs.

The mooring leg turns a top-of-hull mounted uni-directional pulley with a recoil spring. The pulley turns the connected flywheel during upward hull movement and the recoil spring rewinds the mooring legs during downward hull movement. The upper part of the mooring legs are made of a robust long lasting corrosion resistant steel reinforced rubber belt like those used in automobile engines. Rubber is resistant to seawater splash zone corrosion. The uni-directional pulley with recoil spring is similar to the starter system on top of manual start rope pull lawn mower. The flywheel preserves the momentum the same way that the wind turbine rotor blades preserve the wind turbine momentum. An articulated pulley is used to accommodate the varying inclination angles of the mooring legs.

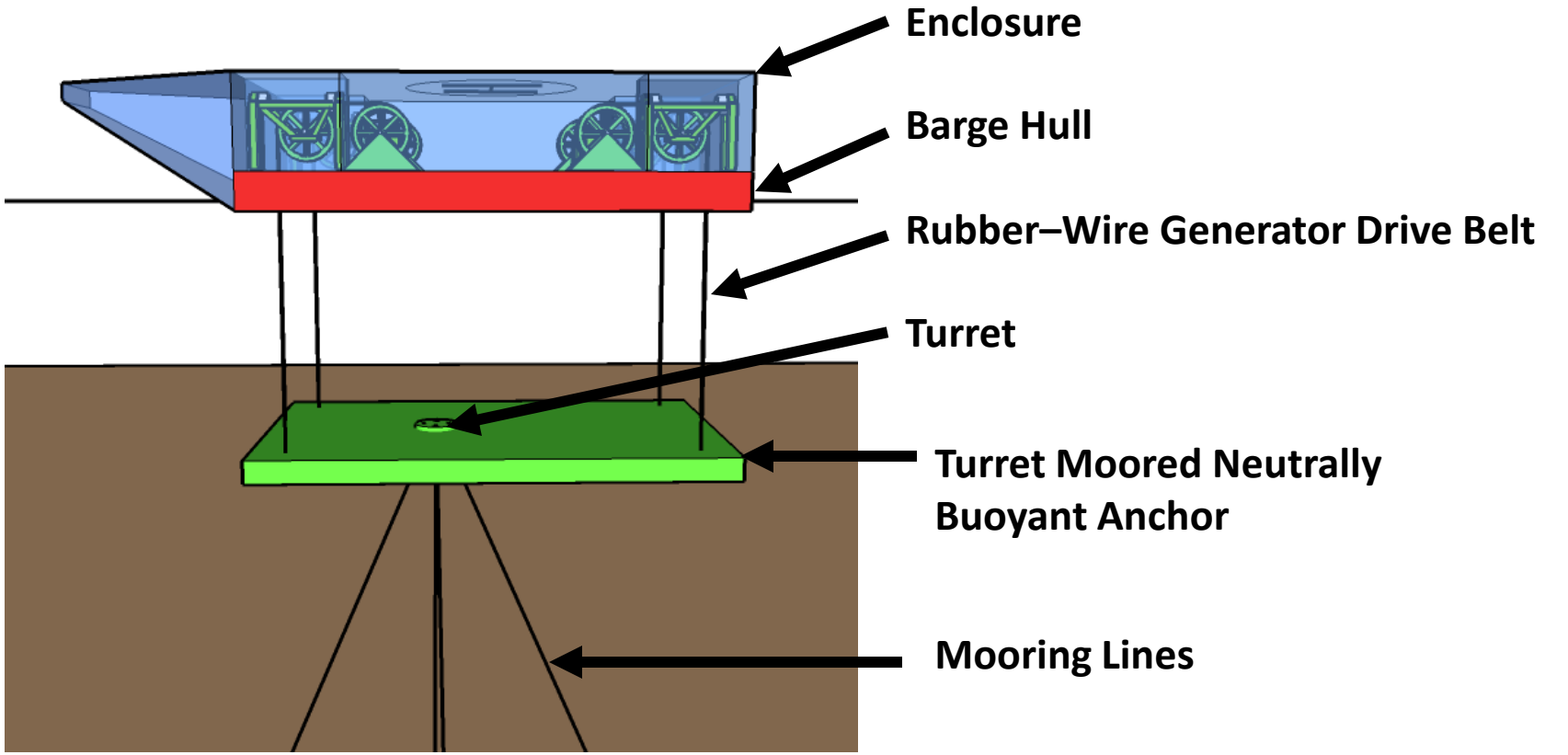
Wave Catcher Barge© Description and Principles
(Continued)

Wave Catcher Barges© :

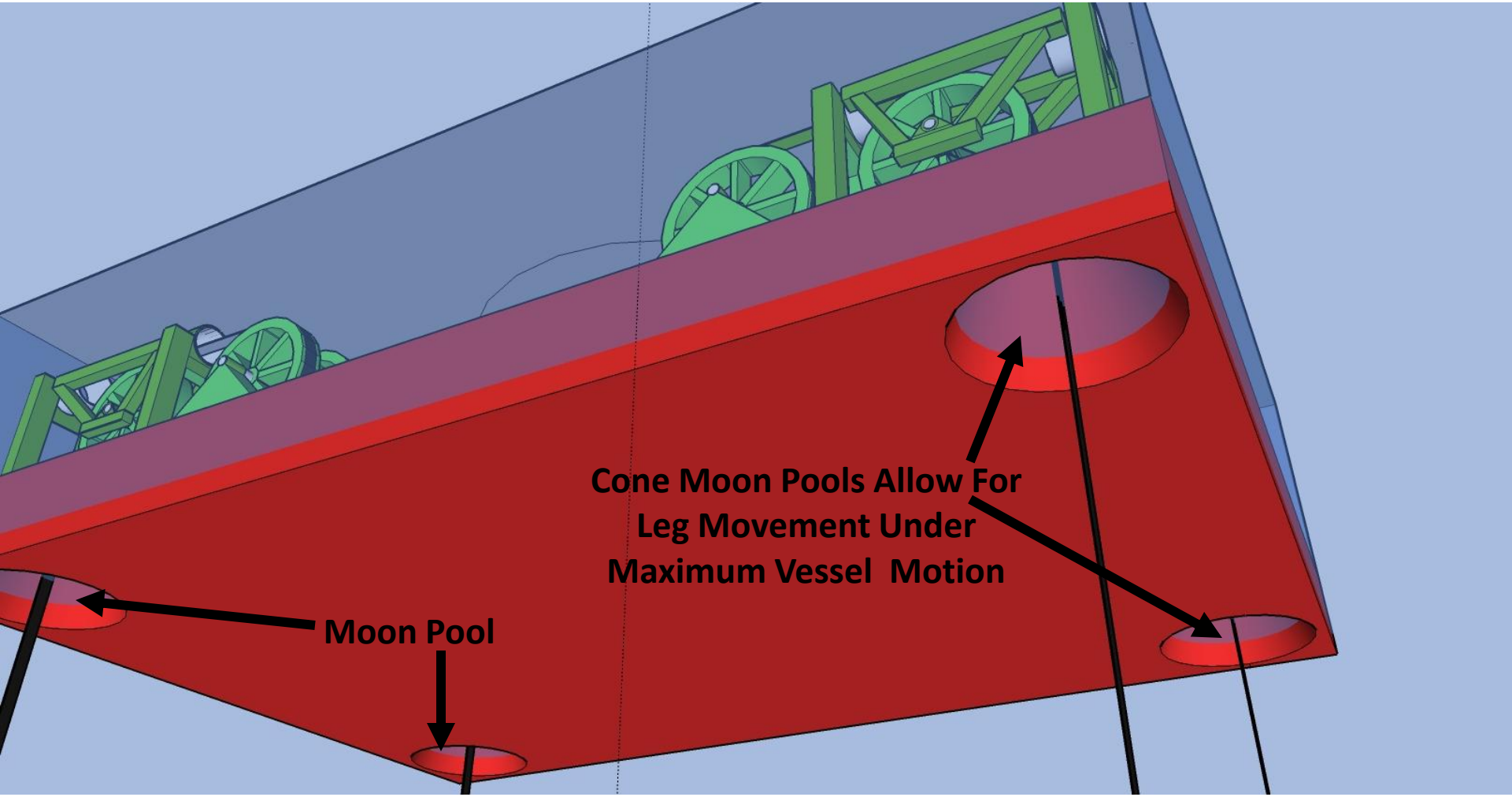
1) uses conventional existing components:
   - a large light low cost flat bottom barge
   - 4 or more high output conventional wind turbine type generators
   - large diameter articulated pulleys, uni-directional pulleys with recoil springs and flywheels
   - conventional offshore mooring systems
2) convert the vertical pressure on the bottom of the barge into significant power since swell waves will lift the barge almost the same height as the swell waves. The barge's large flat high vertical drag coefficient bottoms provide a low cost way to catch the large vertical forces in swell waves.
3) are lifted the approximate height of the swell waves, which are usually 5 to 10 seconds apart;
4) mooring systems turns wind turbine type generators after going over large diameter pulleys that provide low energy losses and low fatigue on the belts;
5) upper mooring systems uses wire reinforced rubber belts like those in car engines and since rubber is resistant to seawater corrosion;
6) and their mooring systems can be designed to survive over 100 year return period storms;
7) mechanical and electrical components are located above water and mostly in a safe dry enclosure;
8) only need a tug and an ROV to be installed and replaced after future onshore refurbishment;
9) can support power cables to the seabed and, in deep water, can support catenary draped power cables further reducing cable costs;
10) allow helicopter and maintenance vessel access for safe above water dry maintenance;
11) provide capital costs similar to onshore wind costs in ideal high swell wave locations ;
12) low profile and the earth's curvature make them difficult to see from shore allowing them to be located near shore without visual pollution.
13) are friendly to the environment by providing a harmless growing surface for marine life.

Turret Moored Wave Catcher Barge With Top of Enclosure Housing 4 Direct Drive Wind Turbine Generators

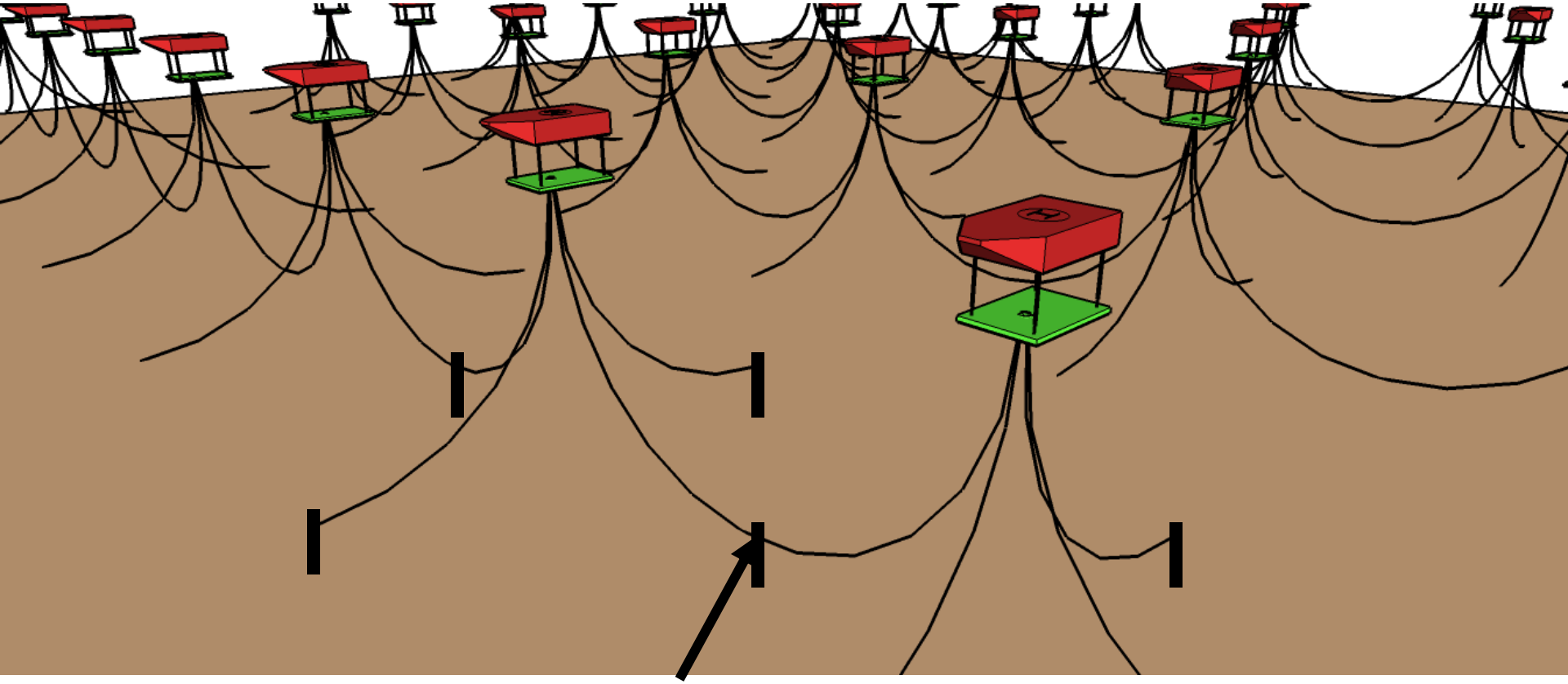
4 wind or more wind turbine type generators are located in a water tight enclosure on top of a barge whose mooring system turns the generators. The barge shown below is vertically moored to buoyant subsurface structure which is turret moored to the seabed. The hull's tapered bow will naturally point into the direction of the prevailing waves. Different barge moorings will be used depending on seabed, water depth, prevailing wave direction, cost, etc.



Enclosure Walls and Roof Are Made Transparent In This View For Illustration Purposes. (This View Is From Under The Barge Looking Up To The Water's Surface.)

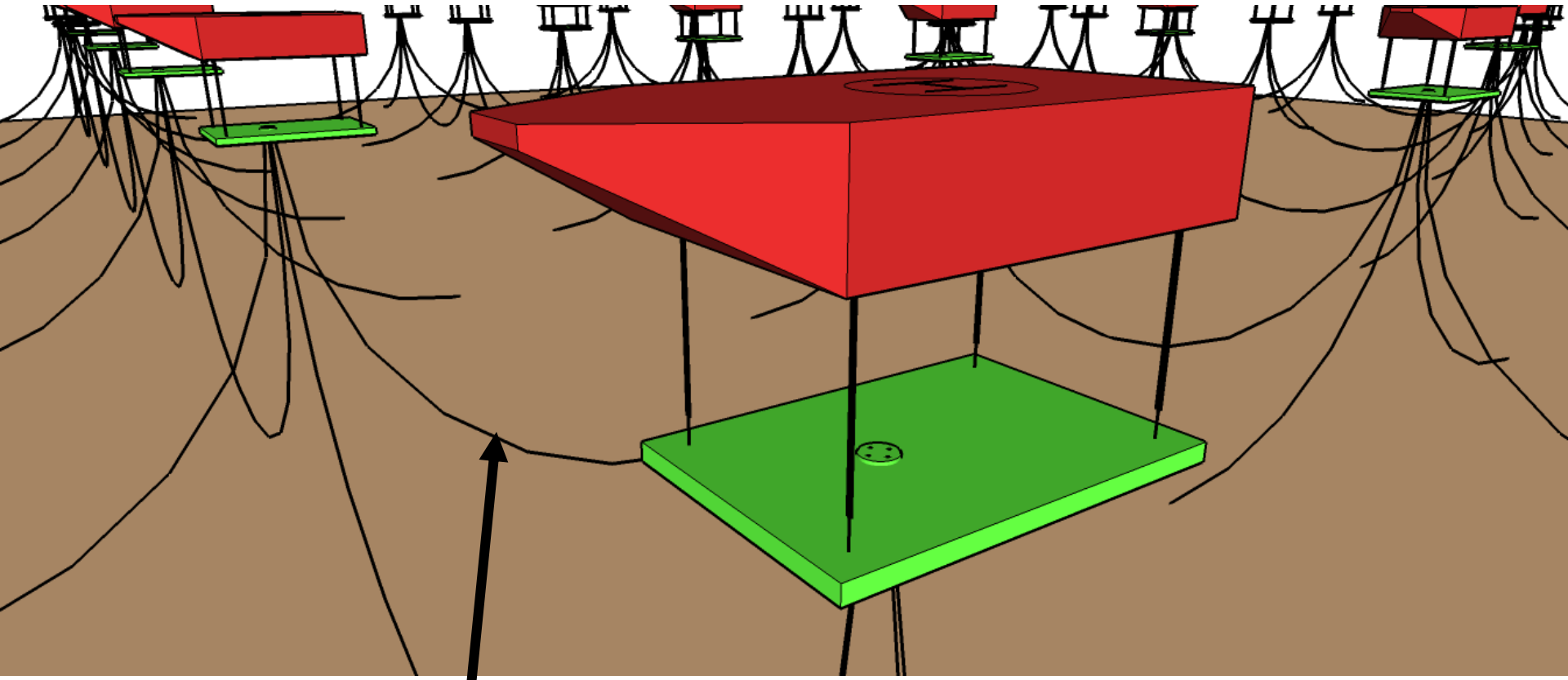


Wave Catcher Barge Power Farm With Turret Moorings (Some Pile Anchor Sharing Is Possible)



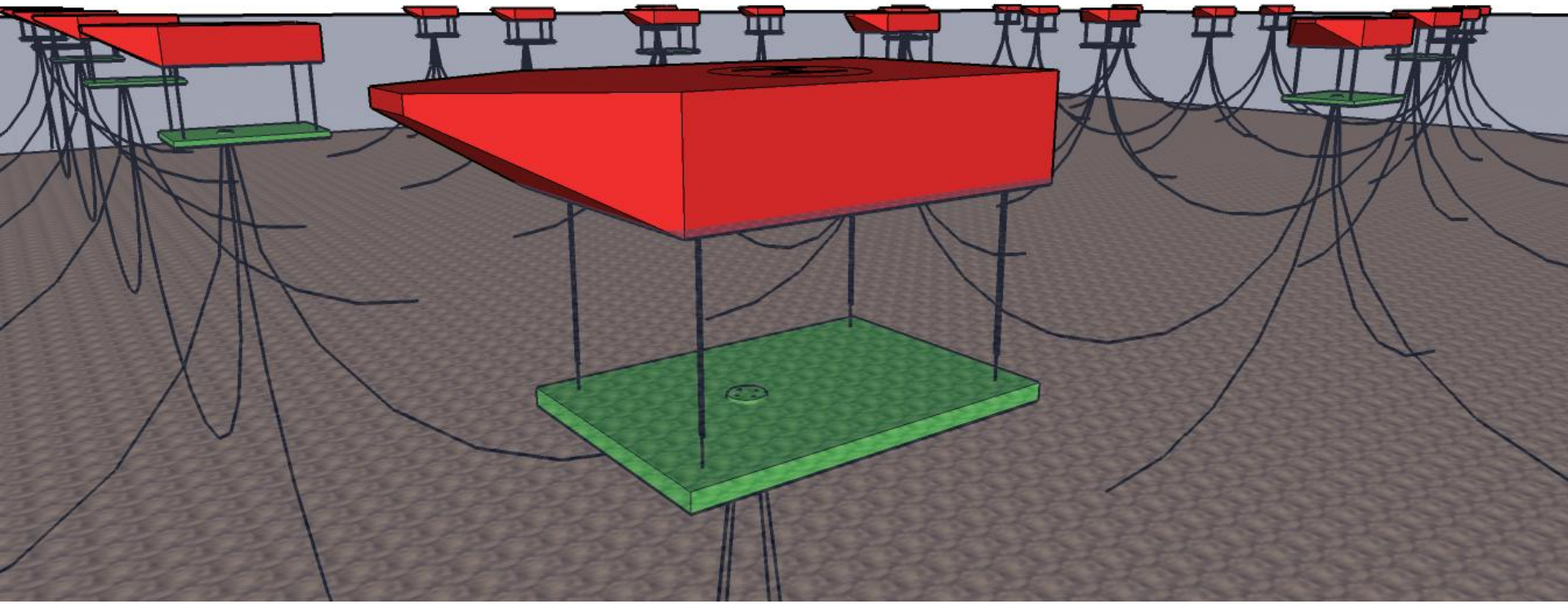
Pile Anchor Sharing Is Possible

Wave Catcher Barge Power Farm With Turret Moorings and Draped Power Cables

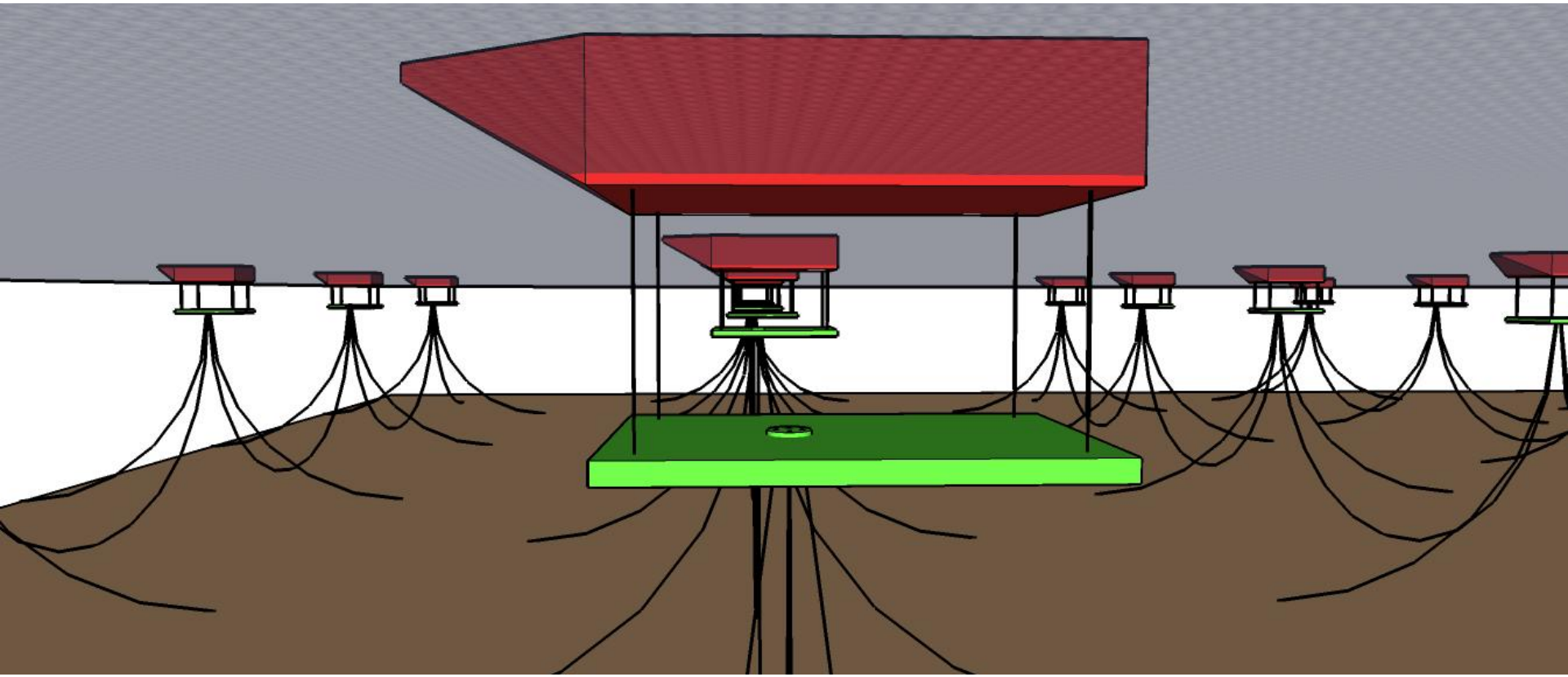


Draped Power Cables Between Turrets

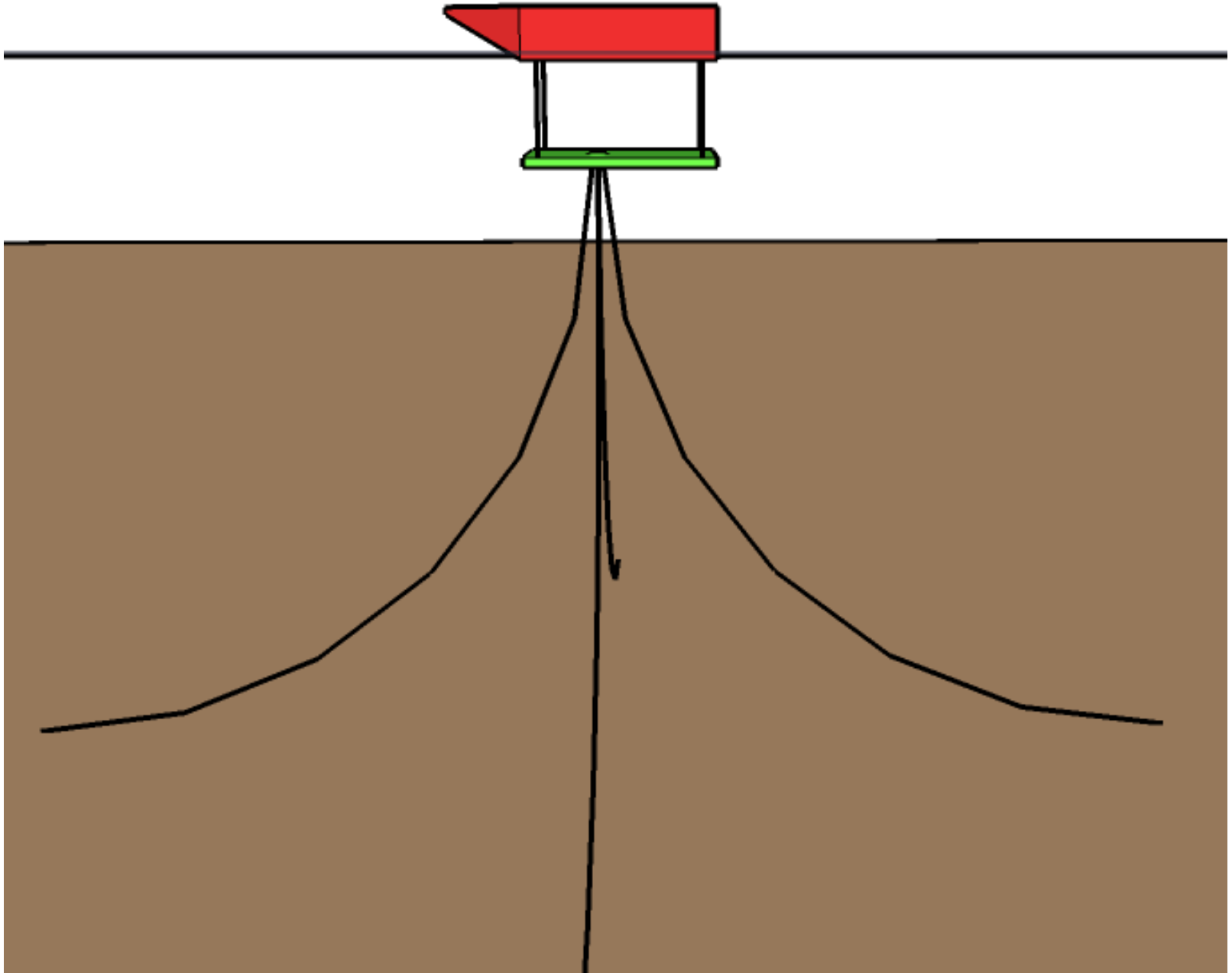
Wave Catcher Barge Power Farm With Turret Moorings and Draped Power Cables



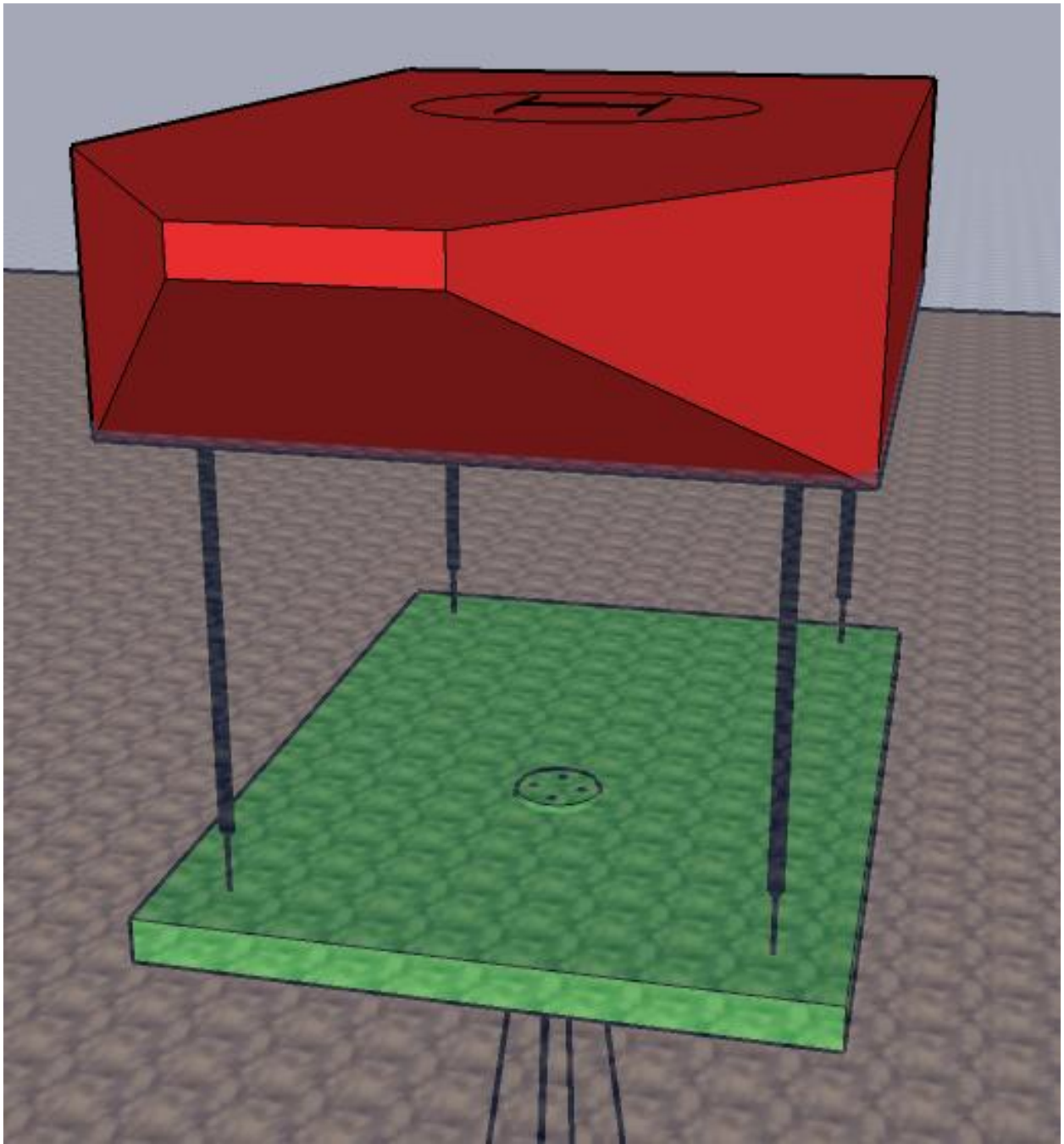
Wave Catcher Barge Power Farm With Turret Moorings and Draped Power Cables



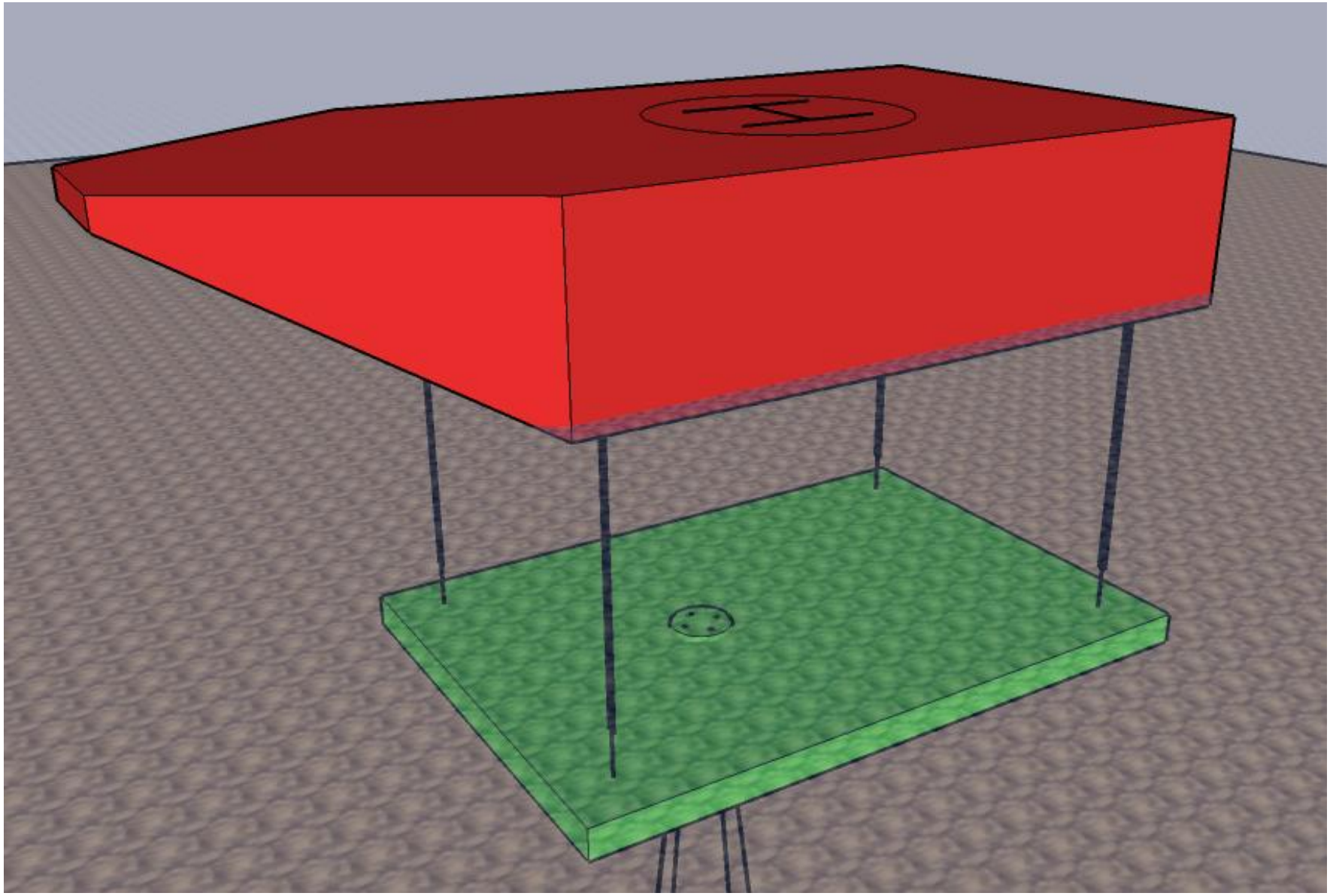
Wave Catcher Barge With Turret Moorings



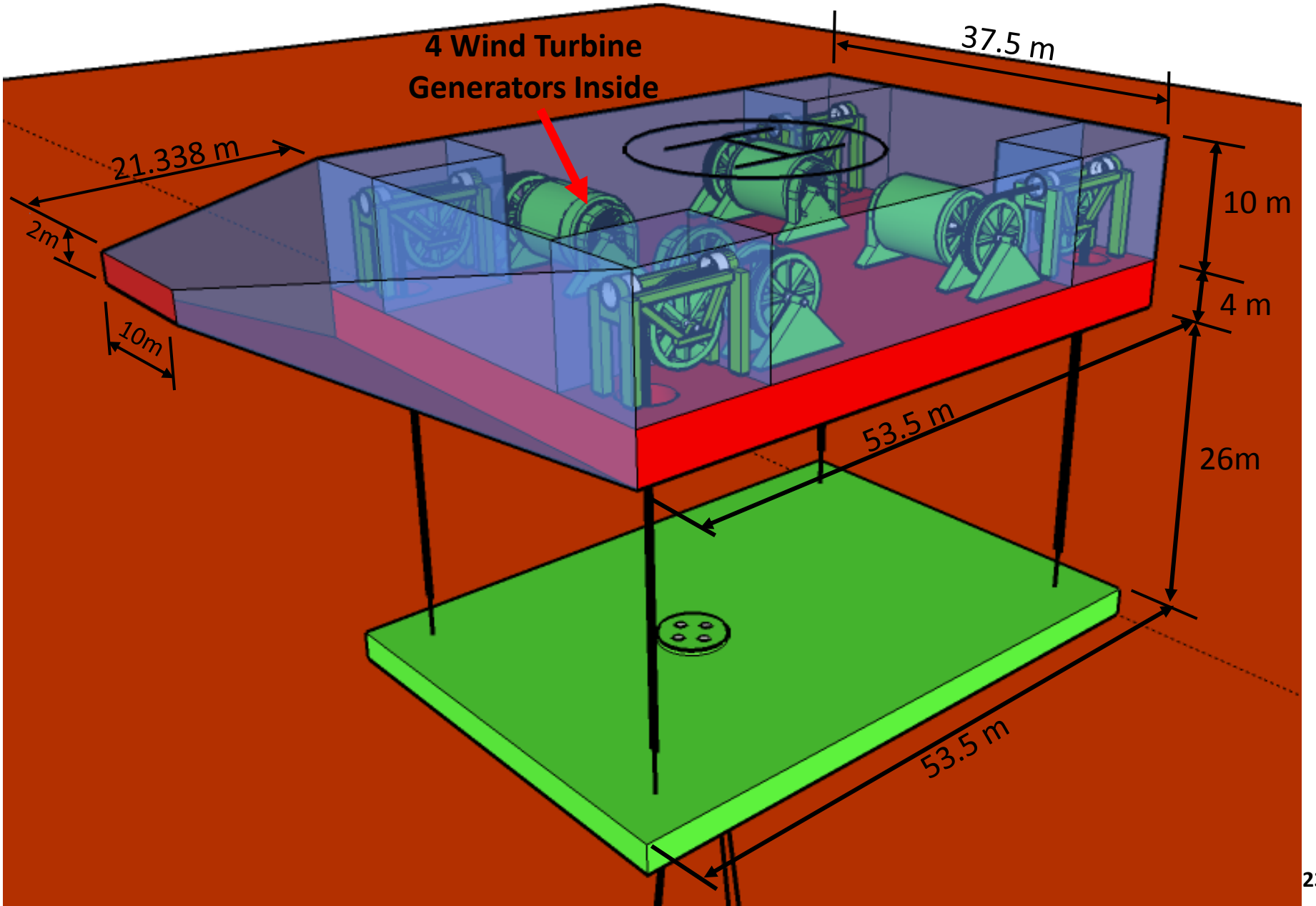
Wave Catcher Barge With Turret Moorings



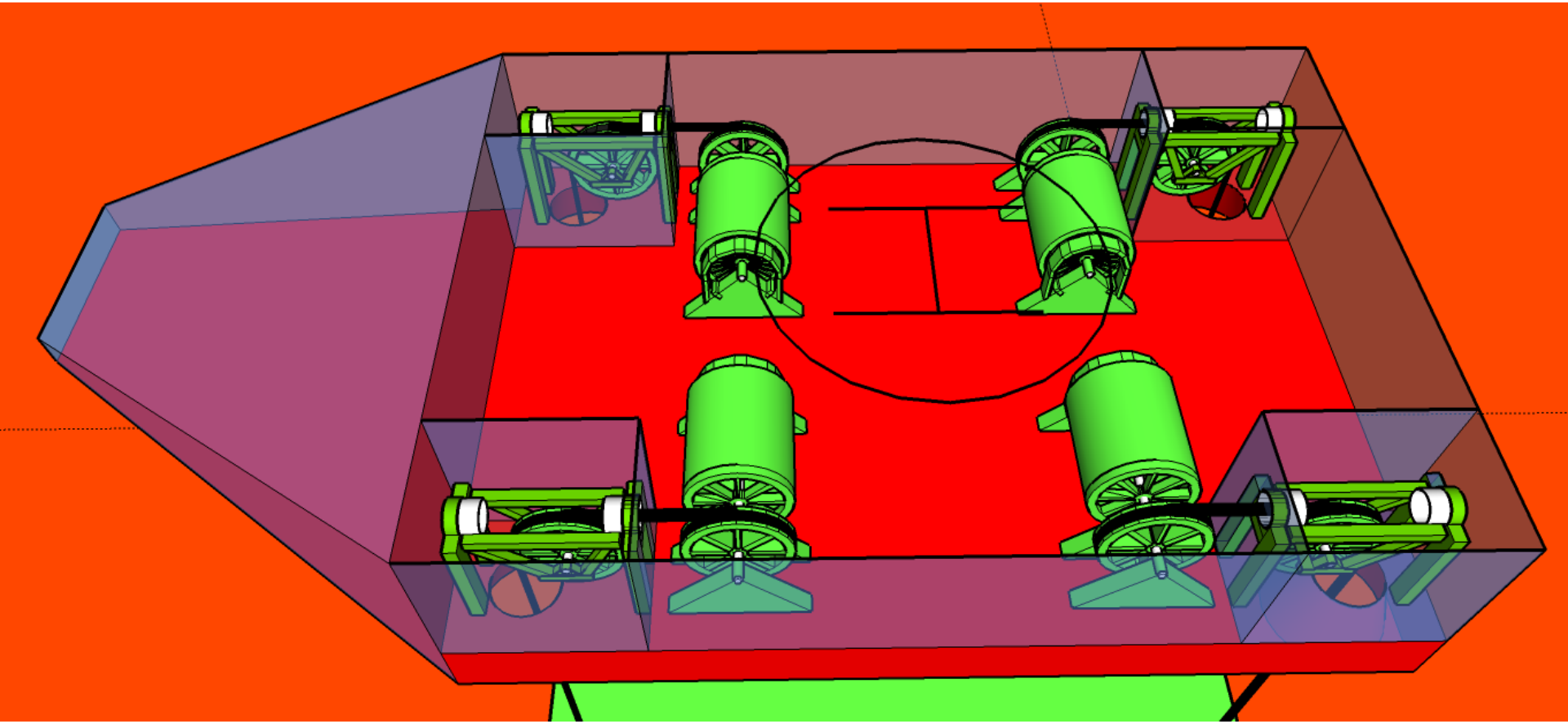
Wave Catcher Barge With Turret Moorings



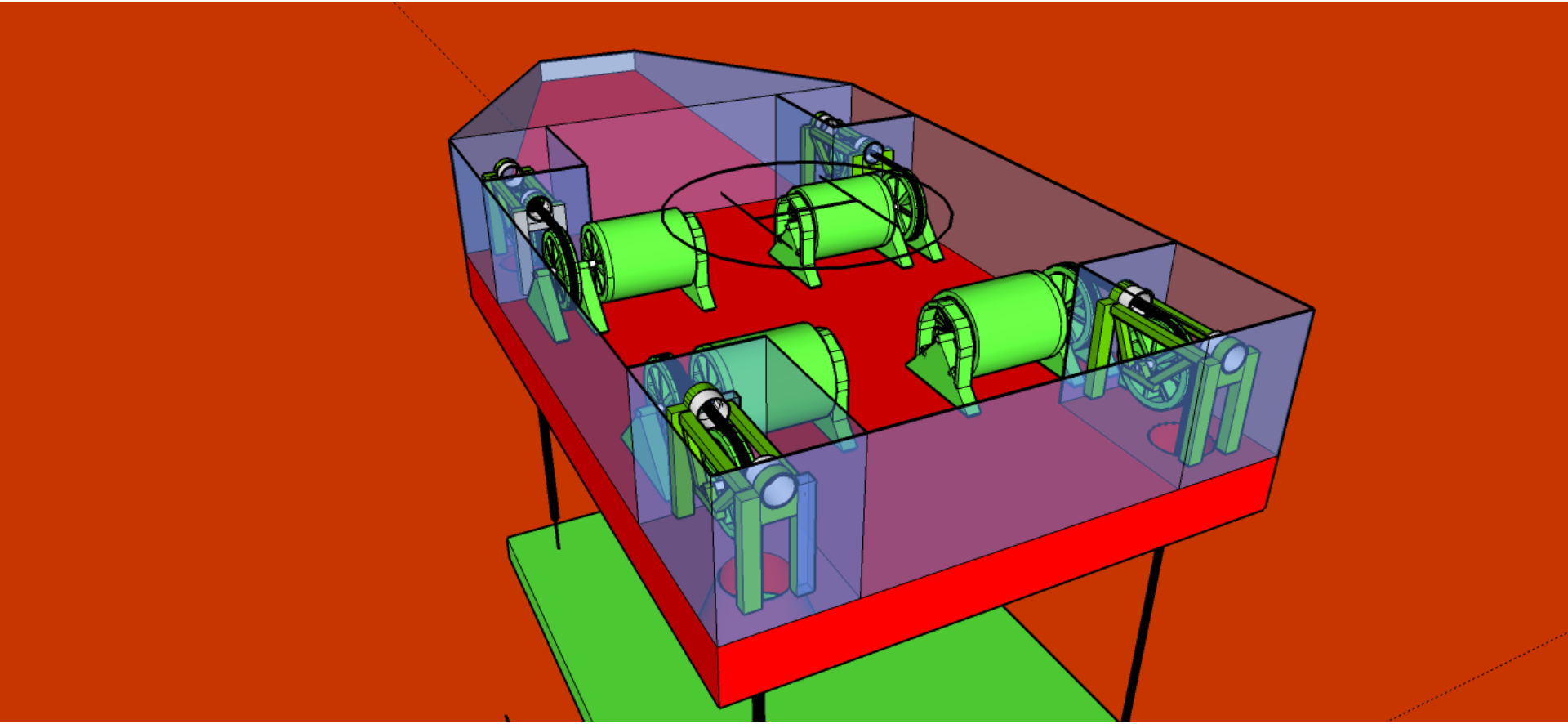
Wave Catcher Barge With Turret Moorings. Shown With Top Enclosure Removed. (Housing 4 Direct Drive Wind Turbine Generators)



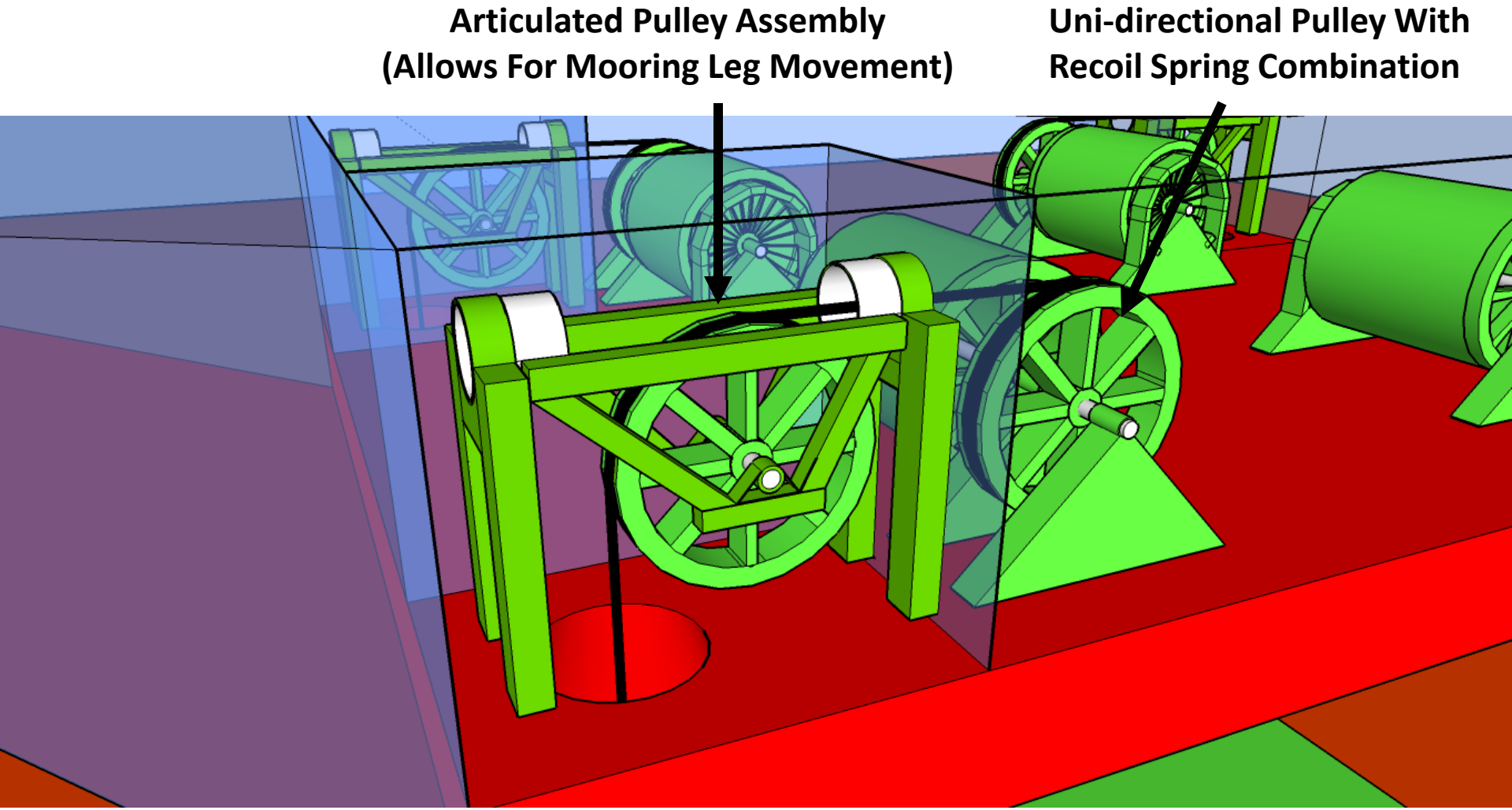
Wave Catcher Barge With Turret Moorings. Shown With Top Enclosure Removed. (Housing 4 Direct Drive Wind Turbine Generators)



Wave Catcher Barge With Turret Moorings. Shown With Top Enclosure Removed. (Housing 4 Direct Drive Wind Turbine Generators)

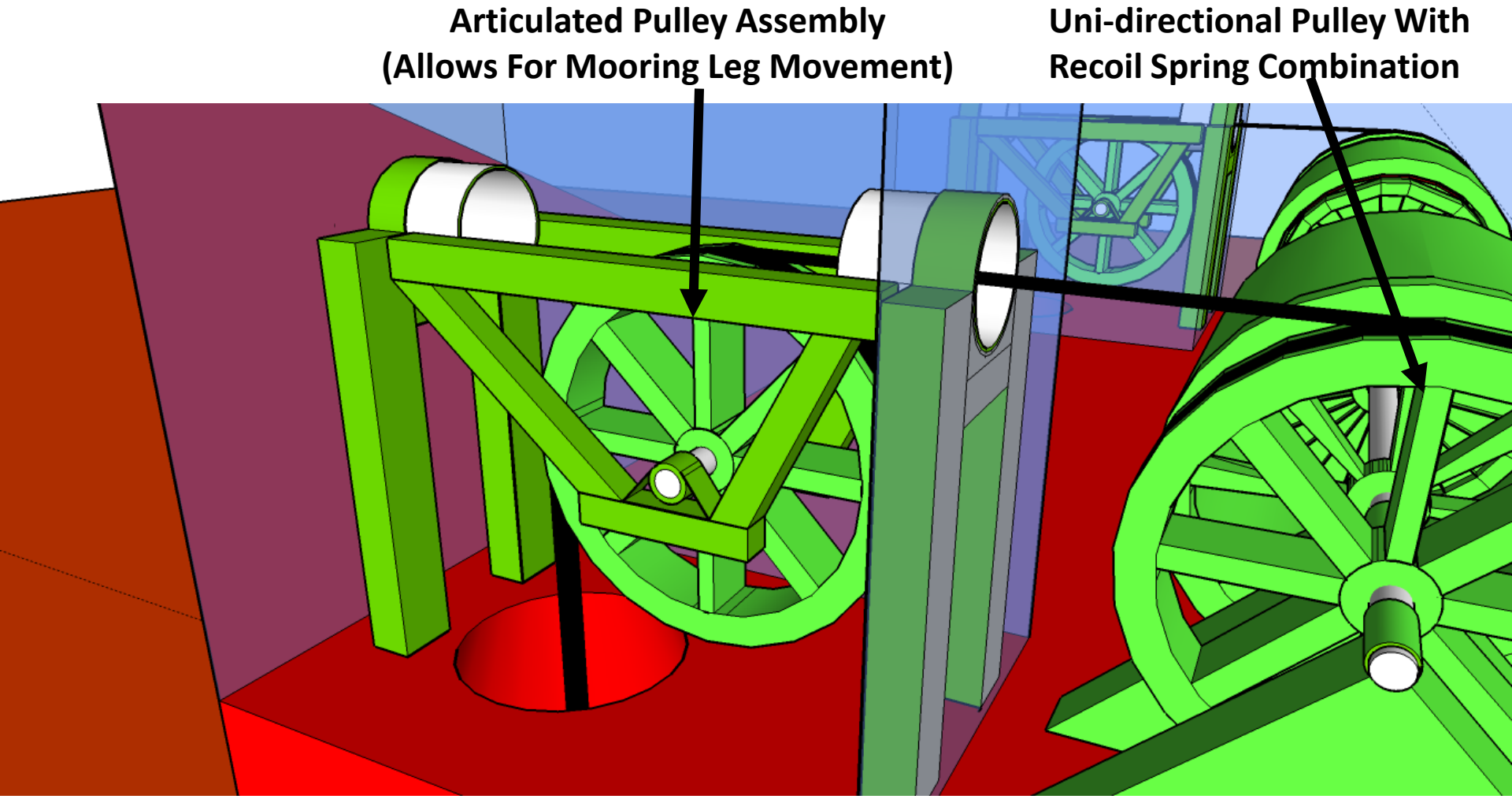


Articulated Pulley And Uni-directional Pulley With Recoil Spring



Uni-directional pulley with recoil spring combination works the same way as the starter rope assembly on a lawn mower. The person pulls the rope which turns the motor. The recoil spring rewinds the rope on the pulley for the next pull on the motor. In the case of the wave catcher barge, the mooring belt turns the direct drive generator - flywheel combination and the mooring belt is rewound back on the uni-directional pulley and recoil spring combination.

Articulated Pulley And Uni-directional Pulley With Recoil Spring



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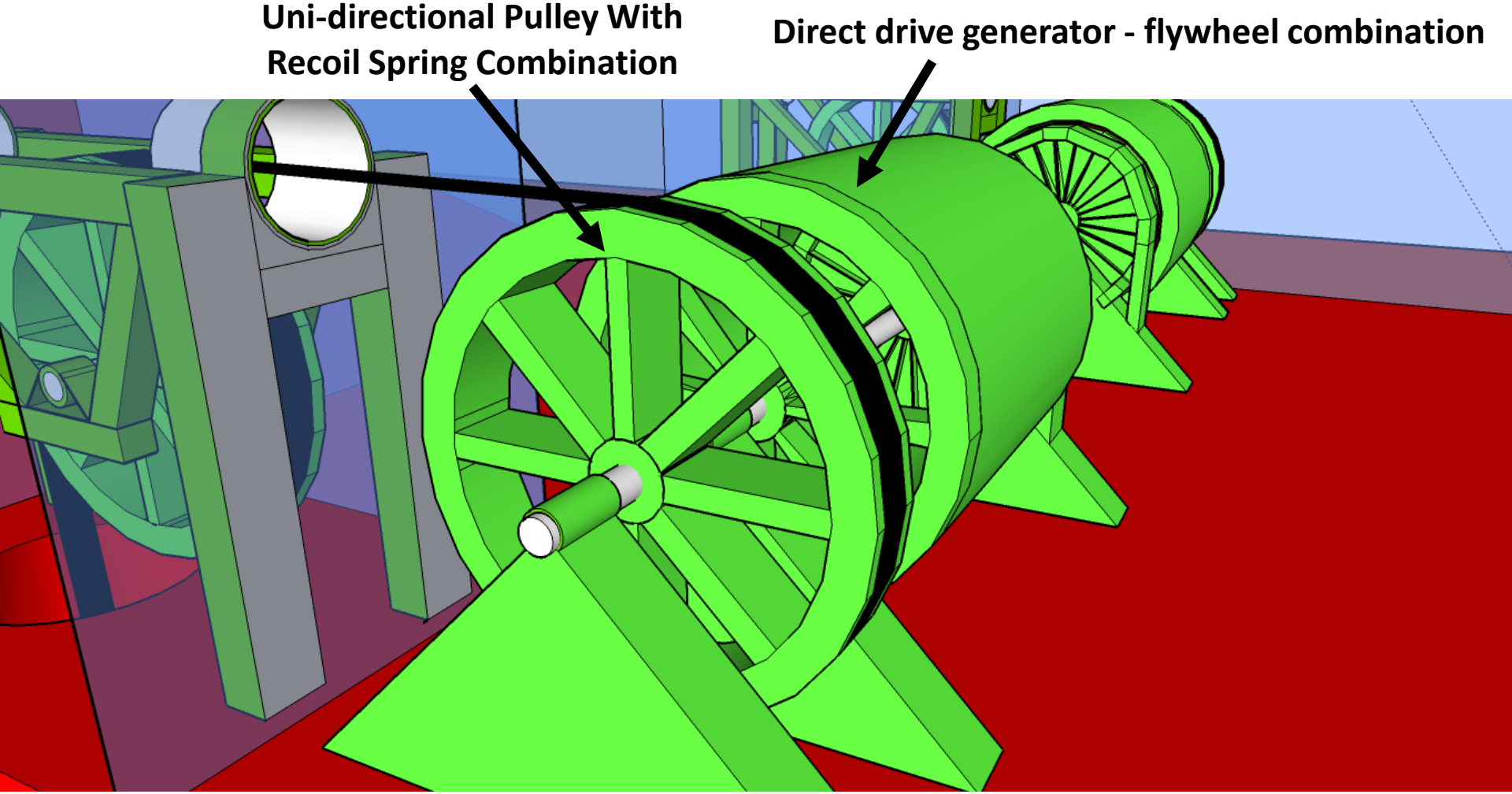
Flywheel Shown With Cover And Uni-directional Pulley With Recoil Spring



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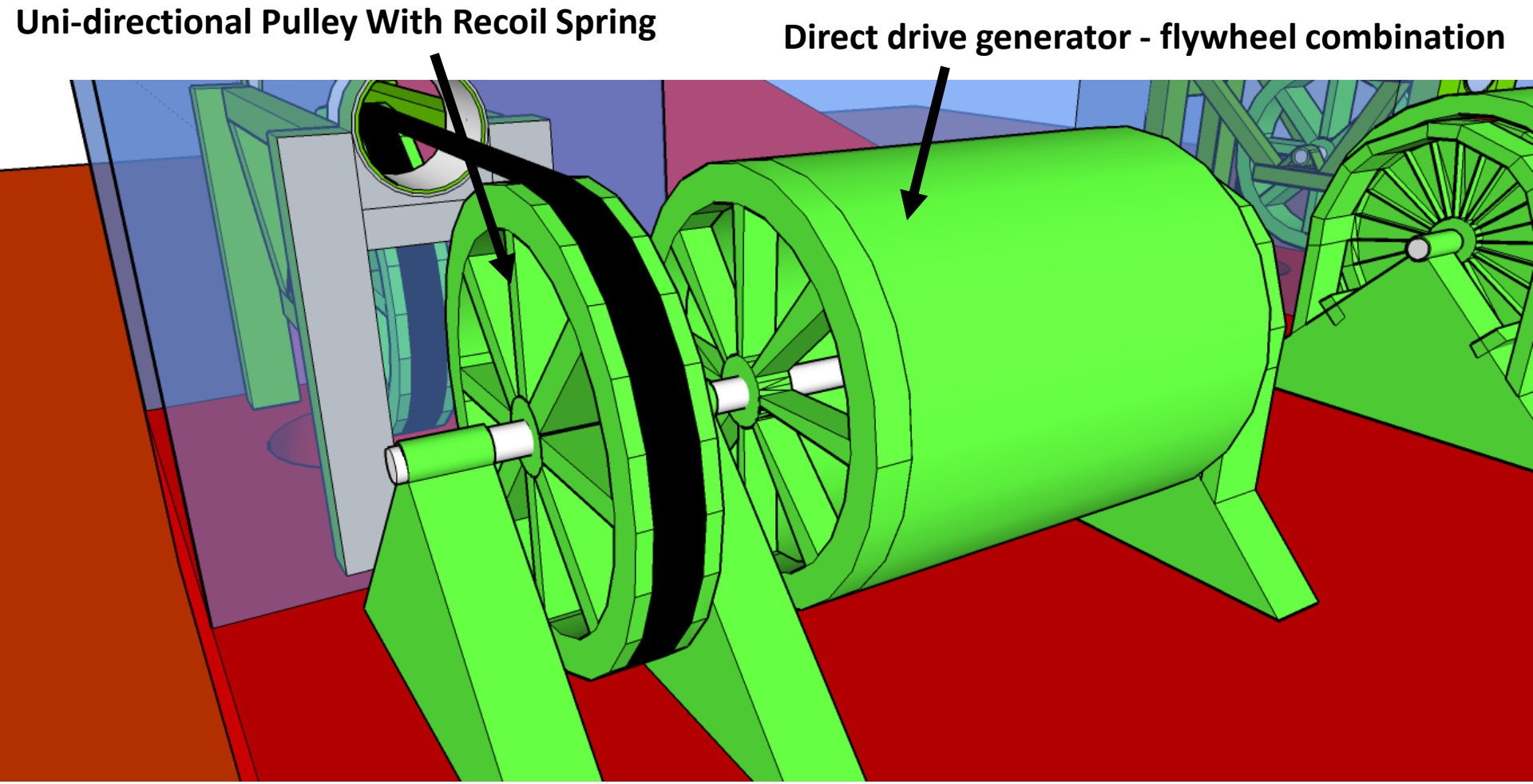

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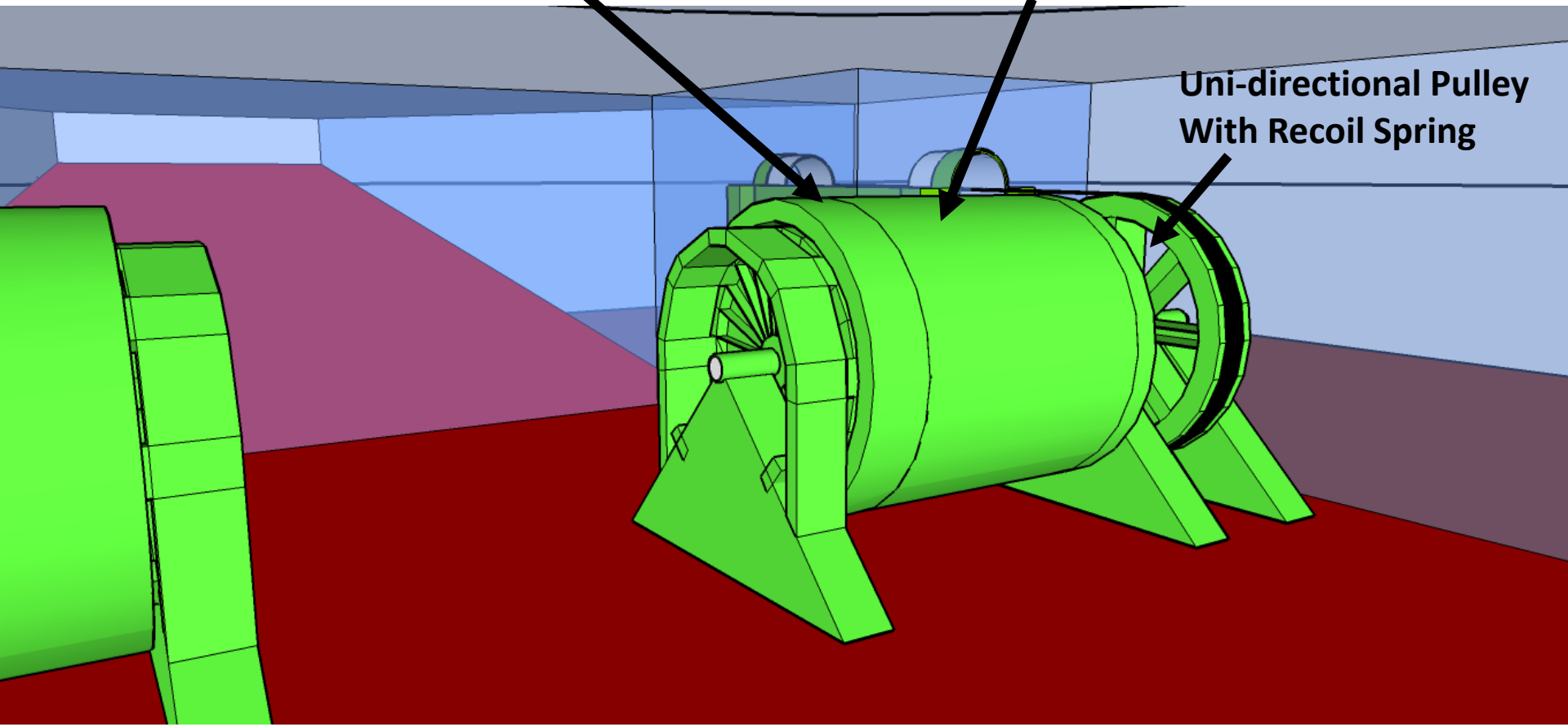
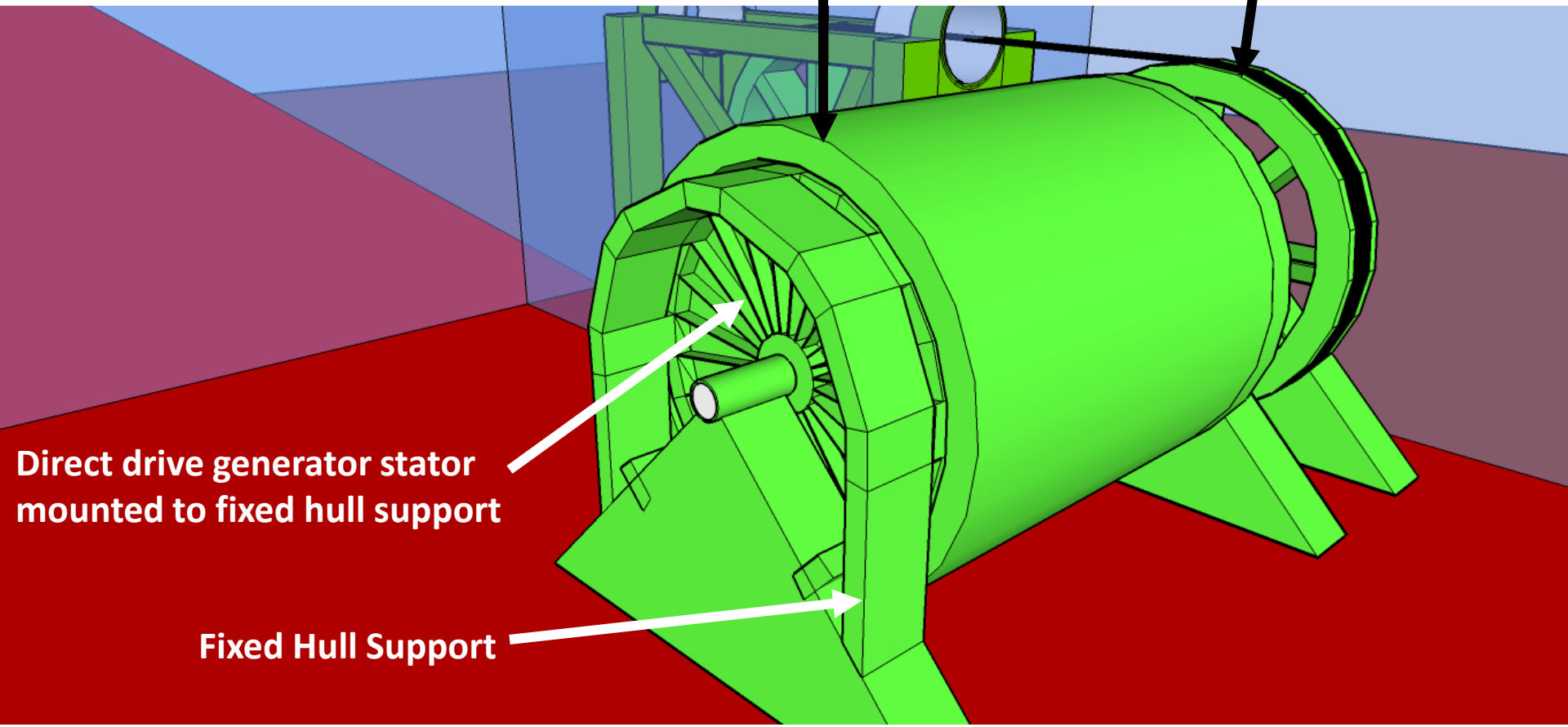
Flywheel Shown With Cover And Uni-directional Pulley With Recoil Spring



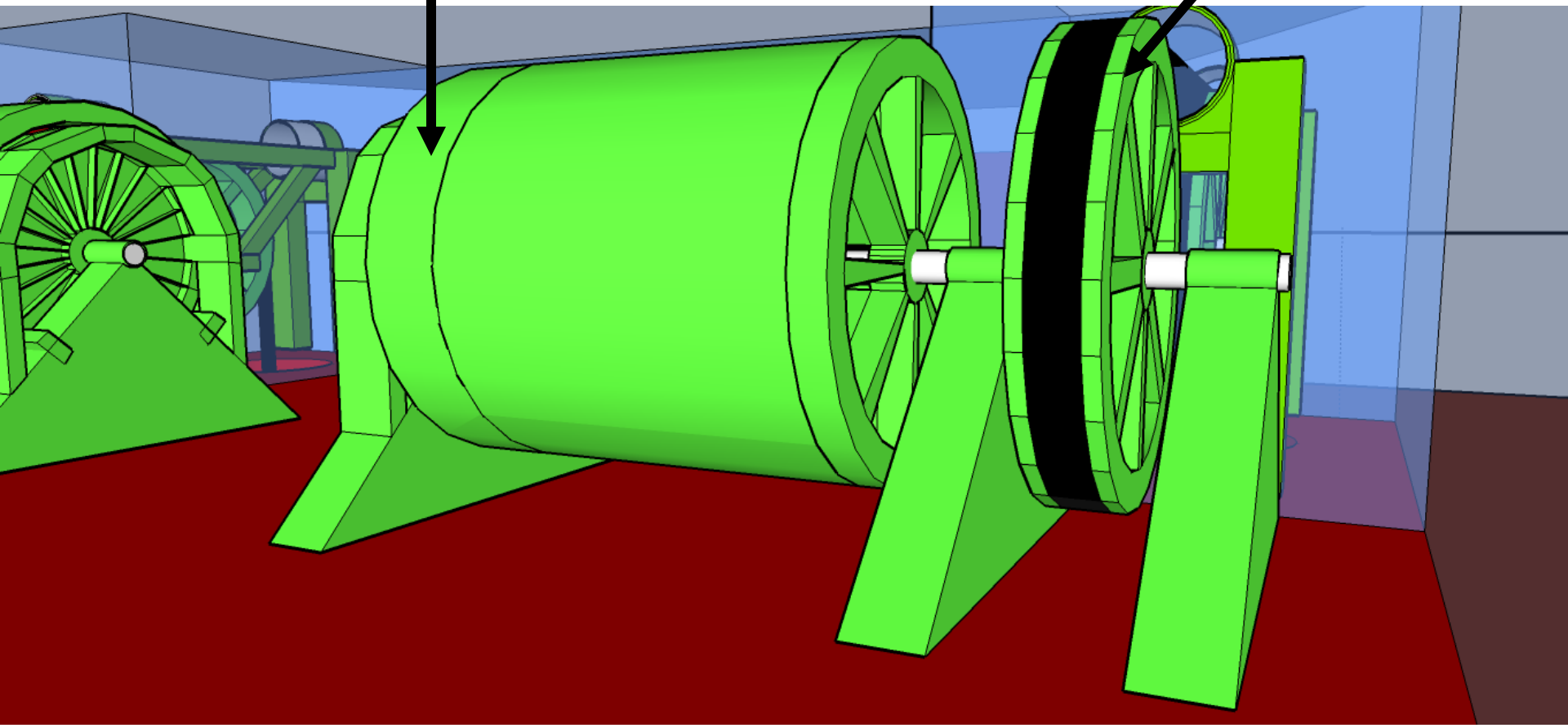
Direct Drive Generator - Flywheel Combination



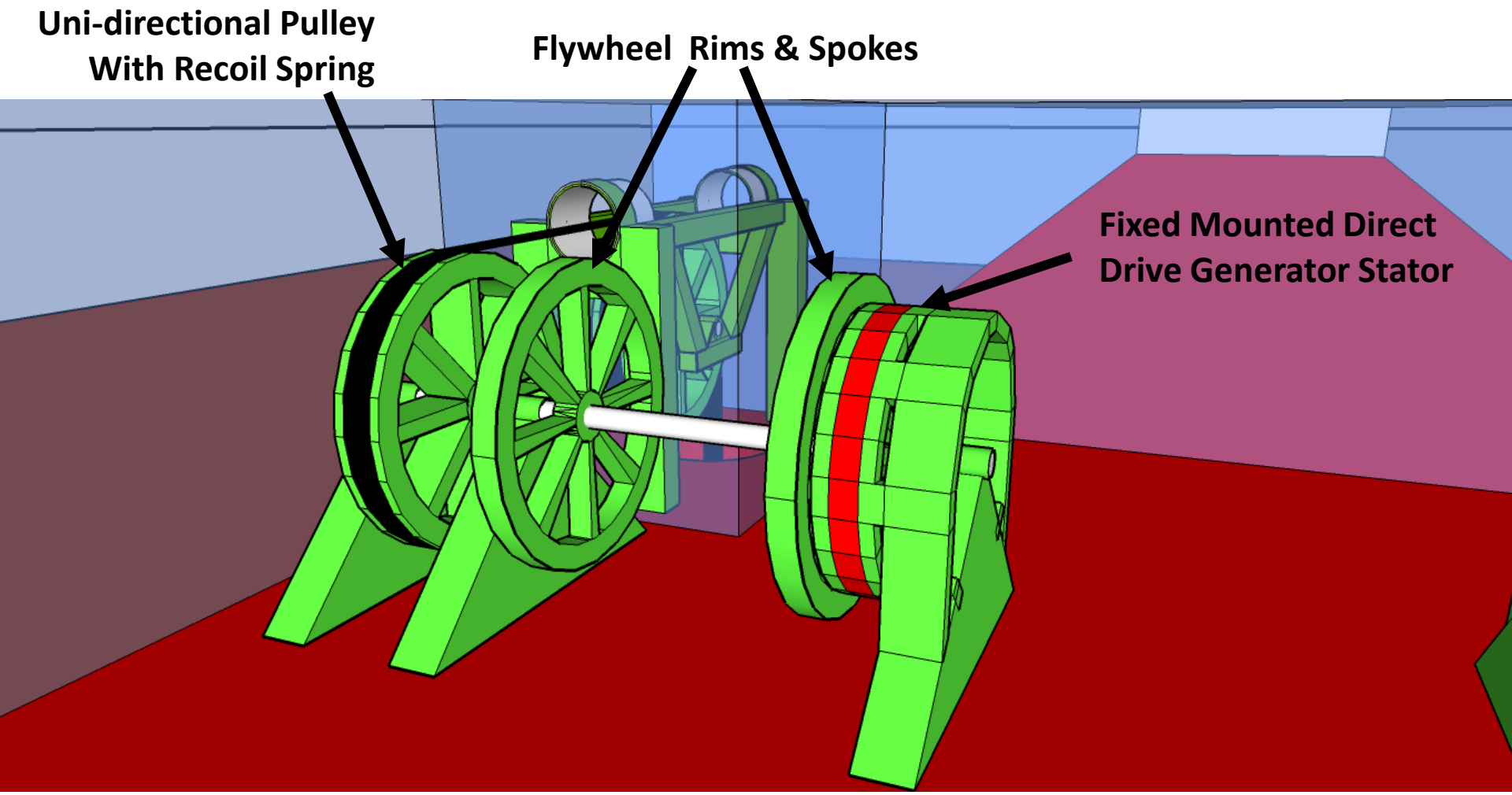
Direct Drive Generator - Flywheel Combination

Flywheel With Attached Direct Drive Generator Rotor

Uni-directional Pulley
With Recoil Spring

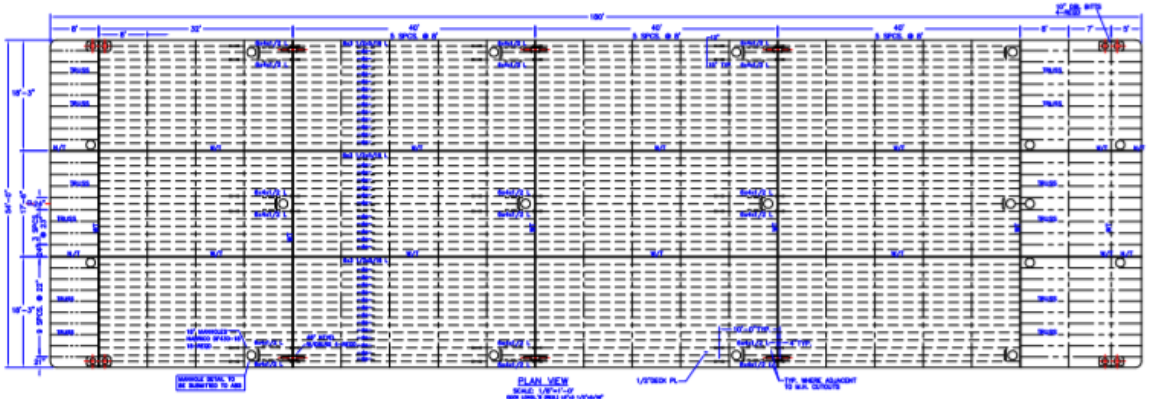


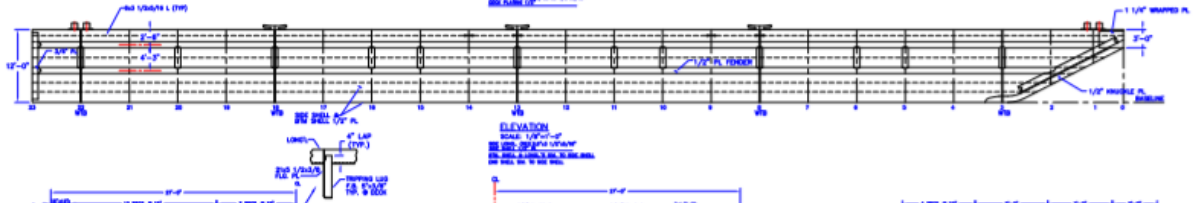
Direct Drive Generator - Flywheel Combination
(Shown With Flywheel Cover and Rotor Removed)

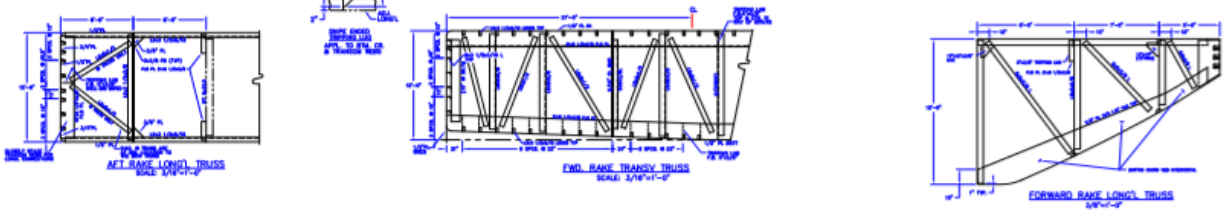


Wave Catcher Barge MTO Based On CBC 759 Barge Design

This deck cargo barge's plate thicknesses and member sizes were used to make an MTO estimate for the wave catcher barge. Other component costs were based on similar existing goby information to make the costs estimates reasonable. Detailed design efforts should make the barge lighter by using the strength of the enclosure, enclosure partitions, lighter deck loading, improved bow design, etc.



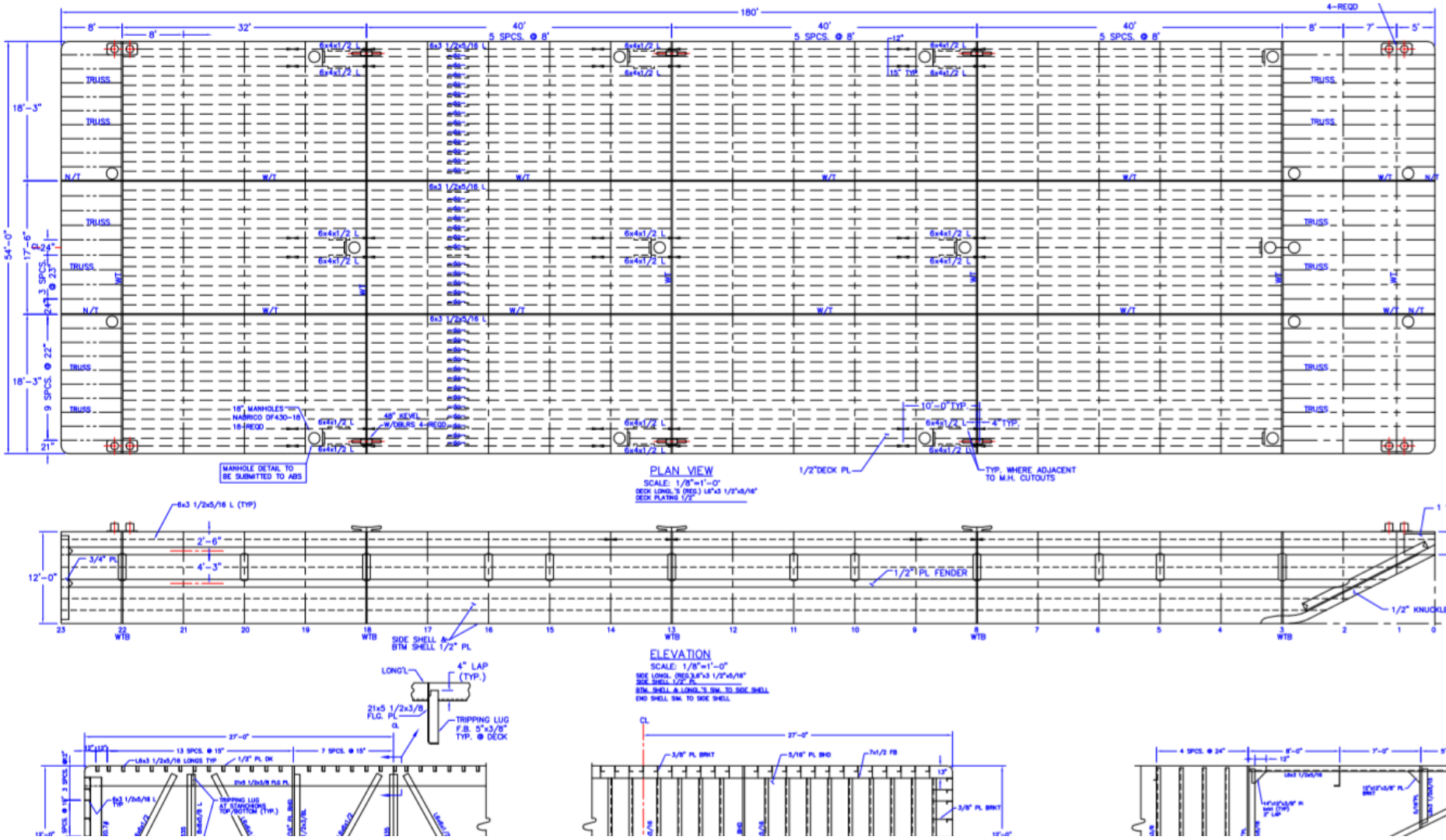




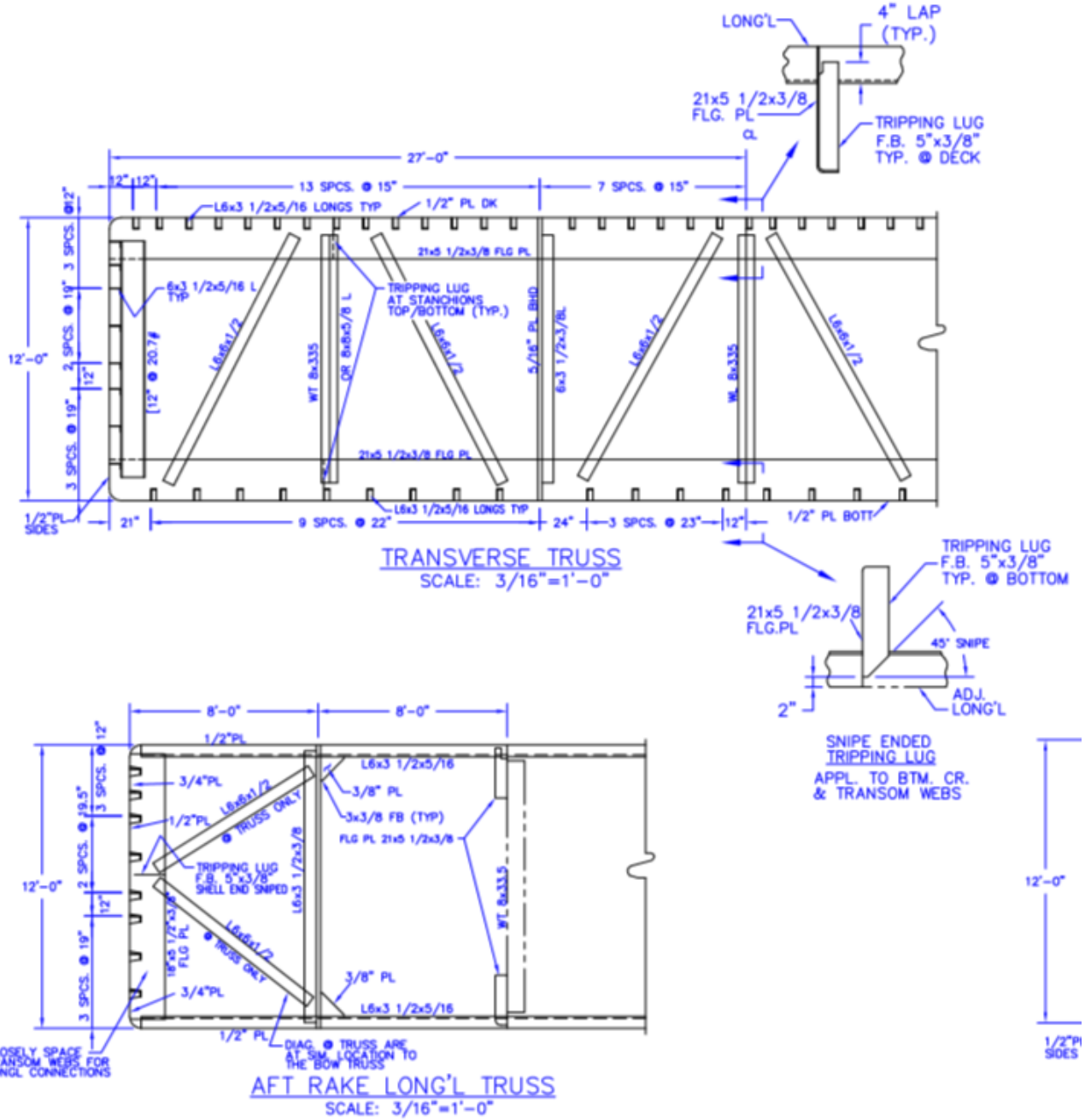
CANAL BARGE
Canal Barge Company, Inc.
835 Union Street
New Orleans, LA 70112
Phone 504.581.2424
www.canalbarge.com

180' x 54' x 12' - 0"
DECK CARGO BARGE
GENERAL/STRUCTURAL ARRANGEMENT
CBC 759 & 760

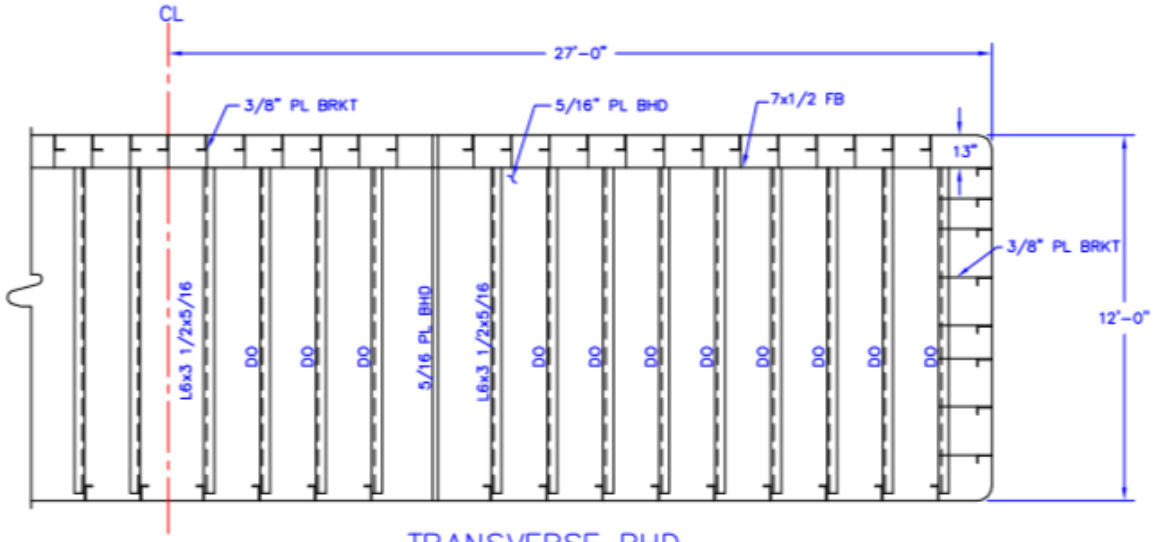
Wave Catcher Barge MTO Based On CBC 759 Barge Design



Wave Catcher Barge MTO Based On CBC 759 Barge Design

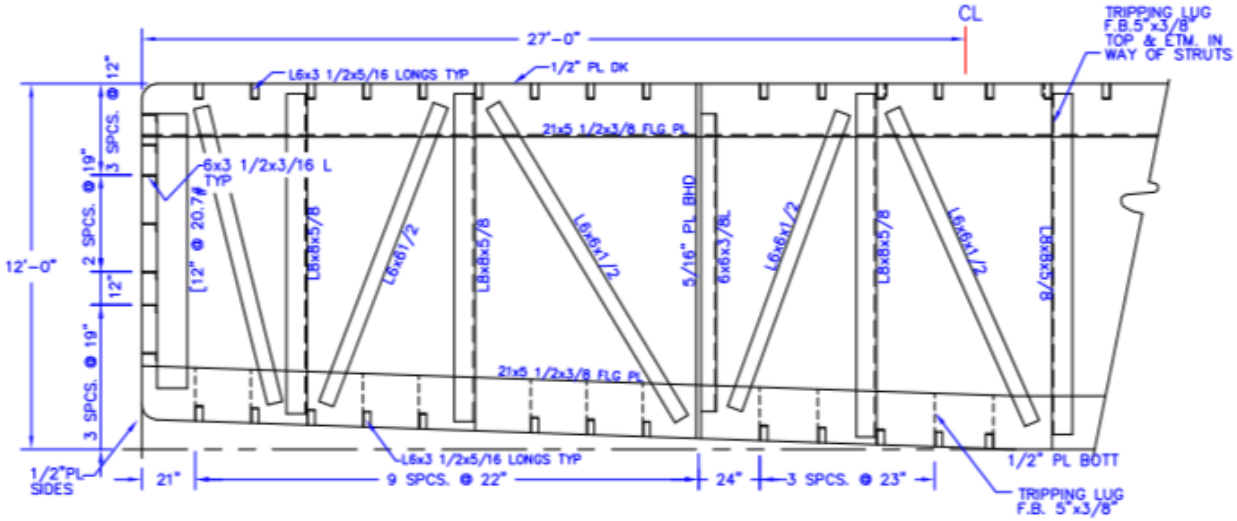


Wave Catcher Barge MTO Based On CBC 759 Barge Design



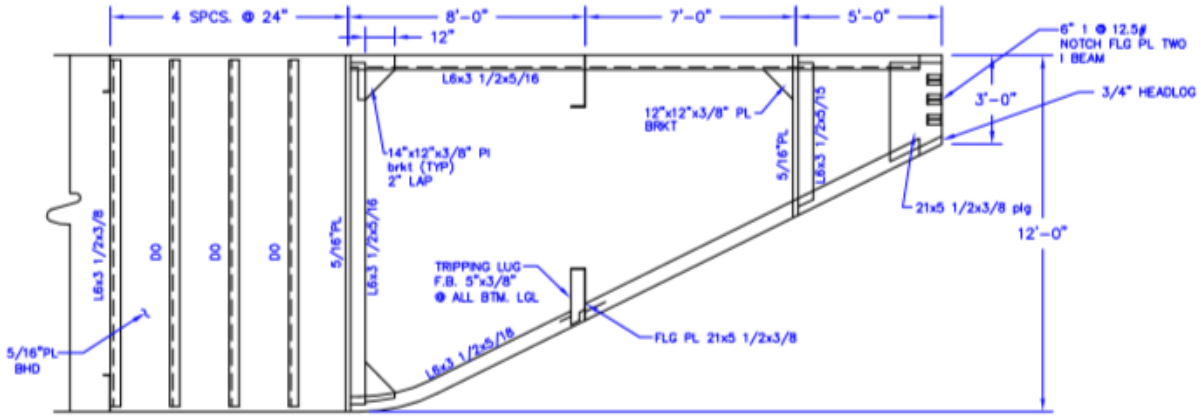
TRANSVERSE BHD
SCALE: 3/16"=1'-0"

LUG
/8"
OTTOM



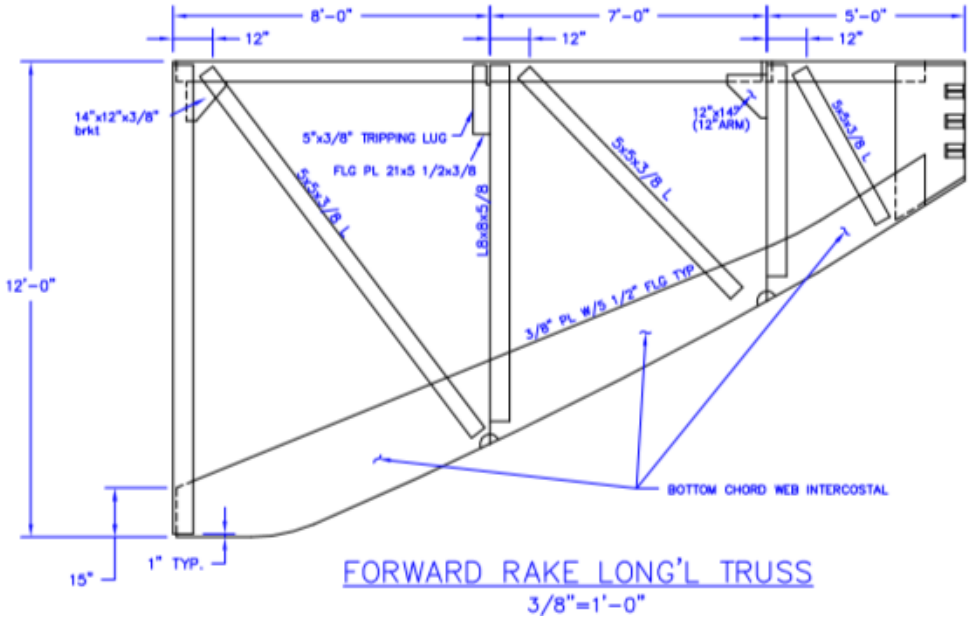
FWD. RAKE TRANSV TRUSS
SCALE: 3/16"=1'-0"

Wave Catcher Barge MTO Based On CBC 759 Barge Design



LONG'L BHD
IWO LONGL BHD
SCALE: 3/16 =1'-0"

FORWARD RAKE LONG'L FRAME
IWO REG LONGL MEMBERS
SCALE: 3/16"=1'-0"



FORWARD RAKE LONG'L TRUSS
3/8"=1'-0"

Wave Catcher Barge Design Development Plan

Phase 0 – Concept Acceptance In Principle

- Design Basis / Power Capacity Assumptions
- Site Assumptions
- Environment Criteria Assumptions
- Base Case Concept Assumptions and Layout
- Design Rules and Regulations Assumptions
- Conceptual Assumptions (Fabrication, installation, HU&C & Operation)
- Sizing Analysis Assumptions
- Global Motions Analysis
- Naval Architecture: Stability, Structural Design
- Mooring Design: Anchor, Mooring Legs and Connectors
- Preliminary Costs and Economics
- Preparation for Phase 1 Engineering

Wave Catcher Barge Design Development Plan

Phase 1 -Concept Design Development Phase (Pre-Feed)

- Design Basis / Power Capacity Requirements
- Permitting and Site Selection
- Environment Criteria Development
- Base Case Concept Selection and Layout
- Design Rules and Regulations Determination
- Conceptual Assumptions (Fabrication, installation, HU&C & Operation)
- Sizing Analysis
- Global Motions Analysis
- Naval Architecture: Stability, Structural Design
- Mooring Design: Anchor, Mooring Legs and Connectors
- Preliminary Costs and Economics
- Preparation for FEED Phase

Wave Catcher Barge Design Development Plan

Phase 2 - Feed Design Phase

- Component Designs
- Develop Component Design Loads and Design Criteria
- Develop component design rules and regulations
- Articulated Pulley Design
- Uni-directional Pulley design with recoil spring
- Flywheel design
- Steel Reinforced Rubber Belt Design
- Design weights and loads from all components
- Vessel Layout For Components
- Vessel Sizing For Layout
- Mooring System Sizing For Loads
- Structural Design For Vessel Sizing and Loads
- Vessel Motions Analysis Based On Final Vessel Sizing and Loads
- Model Tank Testing
- Fabrication Planning and Costs Estimates
- Transportation and Installation Planning and Cost Estimates
- Final Costs Estimates and Economic Analysis Including Permitting
- Contract preparations and negotiation in preparation for contract award
- Final Investment Decision

Wave Catcher Barge Design Development Plan

Phase 3 - EPCI Phase Of Prototype or Full Scale Wave Catcher

- Contract awards
- Detailed designs and drawing of all components
- Fabrication of components
- Fabrication of Wave Catcher Barge Hull
- Installation HU&C of Components on Wave catcher Barge Hull
- Pre-commissioning and Quayside Testing
- Transport to Site
- Installation At Site
- Export Power Cable installation and connection
- Start-up and First Electricity