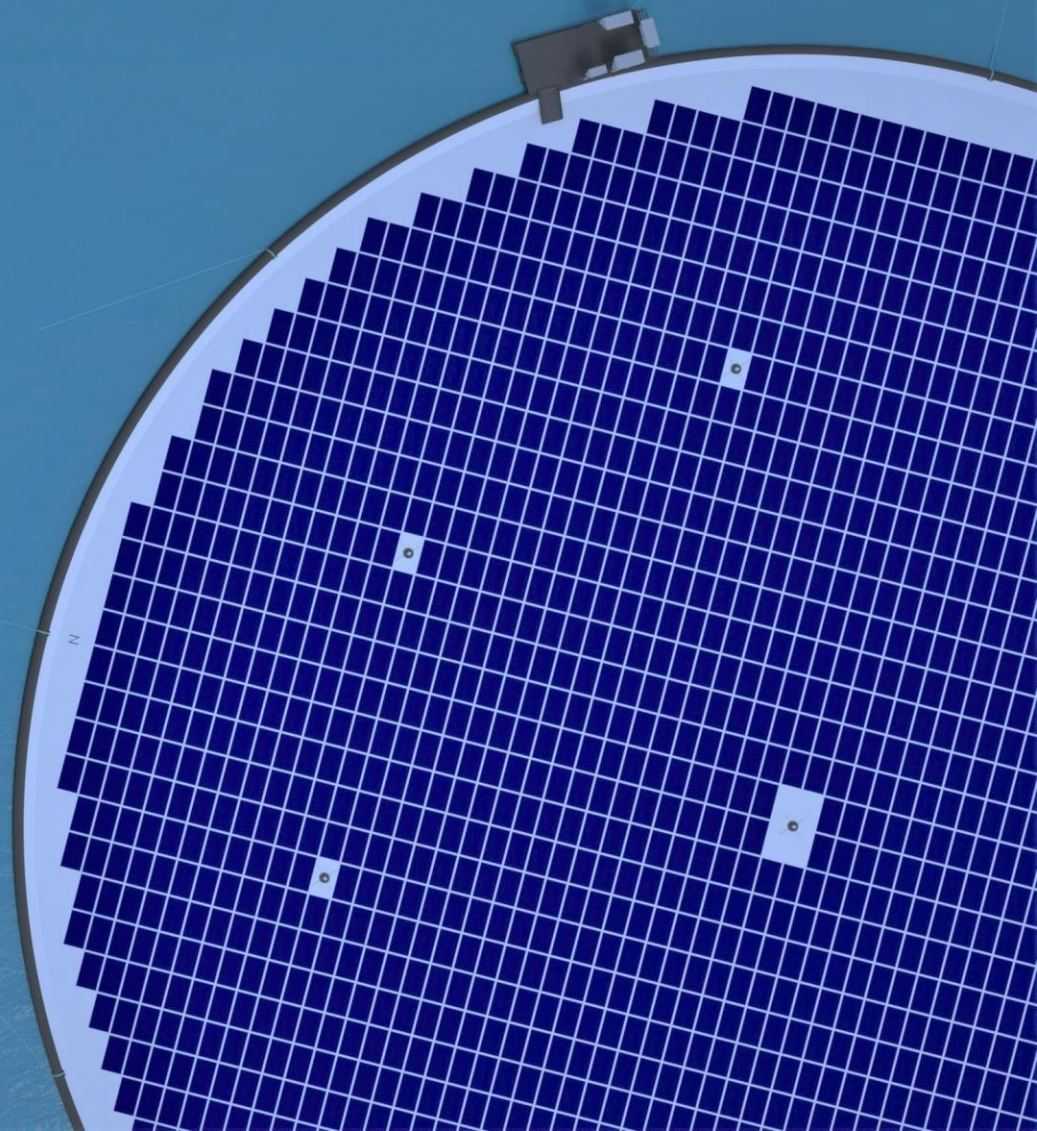
OCEAN SUN

ACEF 2020

Are Gloersen



Why use Ocean Sun's patented solar technology?

Need

Renewable energy

- As the world is electrifying there is an increasing demand for - and dependency on electricity; which share of the total energy mix is forecasted to more than double to 45% by 2050 (DNVGL)
- Simultaneously the Paris agreement and other climate commitments stress the urgency for a transformation to renewable energy sources

Deployment Space

- Traditional solar systems require extensive areas of land which have become a scarce commodity, especially in proximity to demand centers
- The alternative cost is high as valuable land resources could be used for other applications such as agriculture
- Ground mounted PV can also require significant site preparations

Fitting Solution

- The dominating designs for floating PV are not structurally equipped for realisation of the floating PV potential
- Current robust technical solutions are too expensive, as they use significant extra material

Solution

Solar Energy

- Solar power is the most promising of all renweable energy sources and global installed capacity has increased by 95 GW in just 4 years to 140 GW in 2019
- Due to rapididly falling costs, solar electicity generation is expected to grow 65-fold from 1% of total electricity generation in 2016 to 40% in 2050, becoming the single largest provider of electricity in less than two decades

Floating Solar

- Water covers 71% of our planets surface and a majority of the high populated land areas are close to water
- Floating PV installations open new opportunities for scaling up solar generating as no valuable land is used. When Co-generation with hydropower sites, existing electricity transmission infrastructure can be used
- Improved energy yield due to cooling effects from water.

Ocean Sun FPV Solution

- Ocean Sun's solution represents the lowest theoretical cost of a floating PV installation with the potential of realizing an LCOE on par, or even lower, than that of ground mount solutions
- The unique design is more robust and enables large scale deployments in new and existing markets
- Increased efficiency due to direct water cooling

Ocean Sun is a technology provider

Ocean Sun is a technology provider

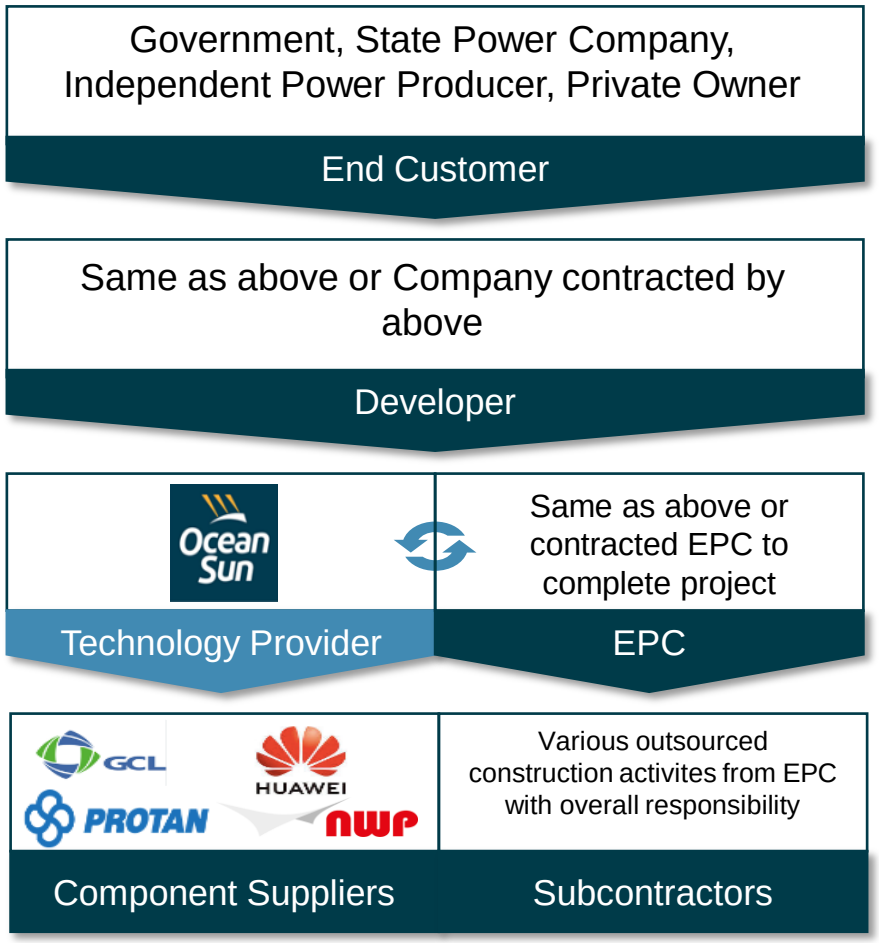
We sell the right to use our patented technology along with:

- Initial engineering finalizing solution design for site
- Bankability documentation package. Detailed method statements including competence specifications as well as initial training of workers
- Detailed BoM, purchase instructions, and attractive prices from our pre-defined material suppliers
- Potential to hire longer support from our personnel

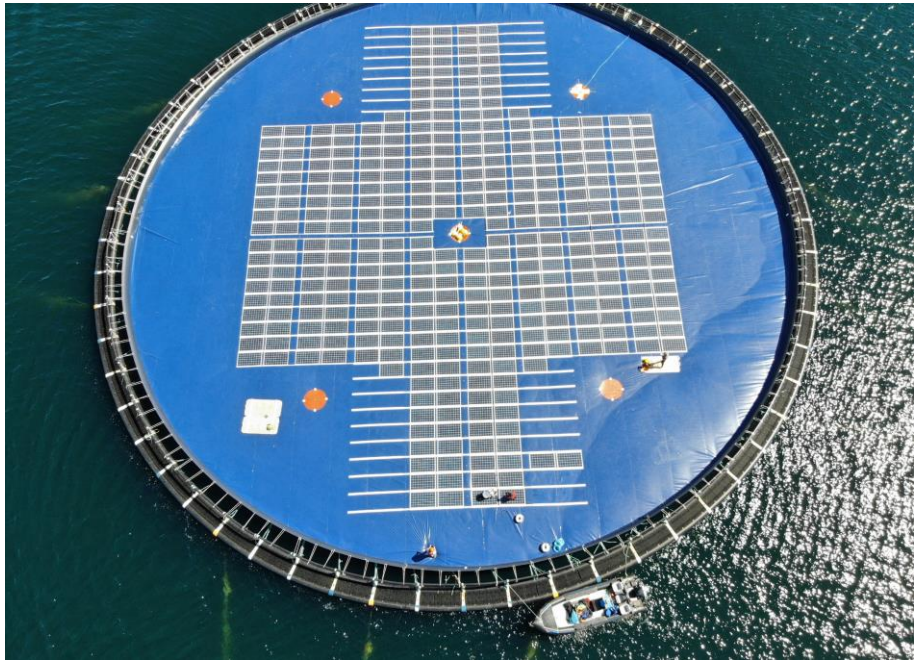
A technology license agreement is signed for each project

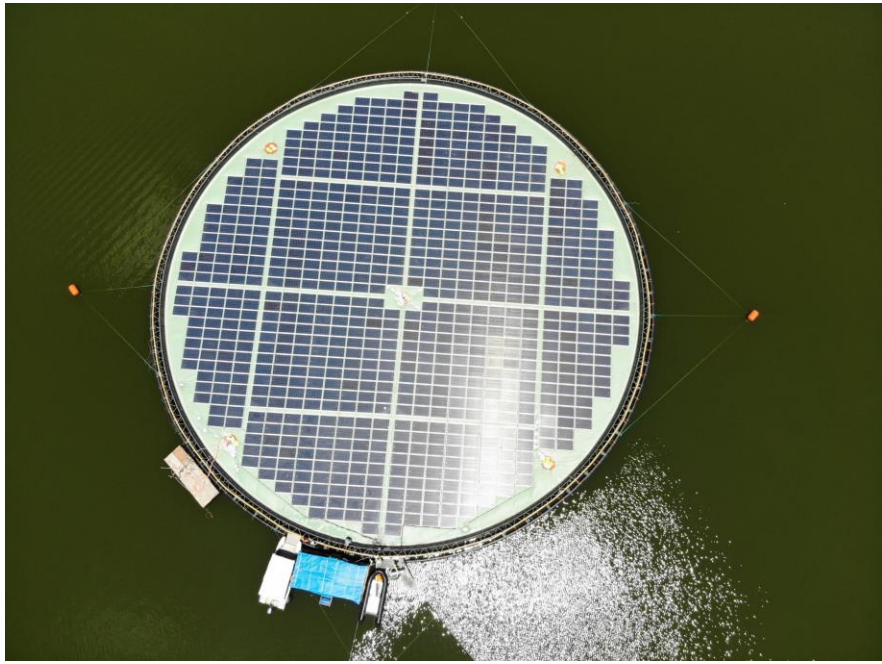
- Specifying the deliveries as described above
- Stating the price consisting of:
  - License fee, payable as $-cent per Wp installed
  - Engineering fee for support on site on an hourly basis

The value chain of floating solar



Past installations prove durability and performance

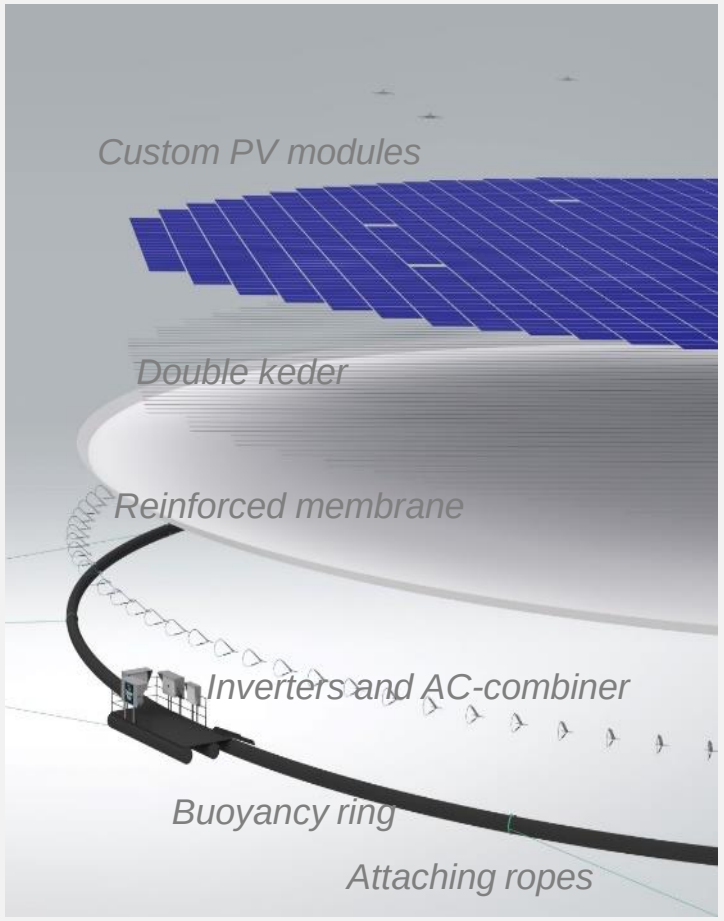




Research institute technology collaborations

Four parallel third party tests validate the system

The Ocean Sun system



Statement of Conformity

First floating PV system to receive a **Statement of Conformity from DNVGL Maritime**

- Conformity on the Design Premise and the structural integrity in waves, wind and currents

DNV·GL Maritime

Durability and conformity of membrane

Together with partners, OS has developed a membrane with:

- Minimum lifetime of 20 years
- No environmental impact on the water

norner The Polymer Explorers
PROTAN

Immersion testing - PID & Insulation resistance

Tests in collaboration with TÜV and GCL to result in:

- Certificate on customized PV modules like IEC/EN 61215.
- GCL to issue a warranty on PV modules

TÜVRheinland® Precisely Right.
GCL

System effectiveness

Collaboration with DNVGL Power & Renewables to:

- Validate PV-modules thermal management performance against that of competing solutions and ground mounted racks
- Generally 8-10% better performance as a result of the heat dissipation to water.

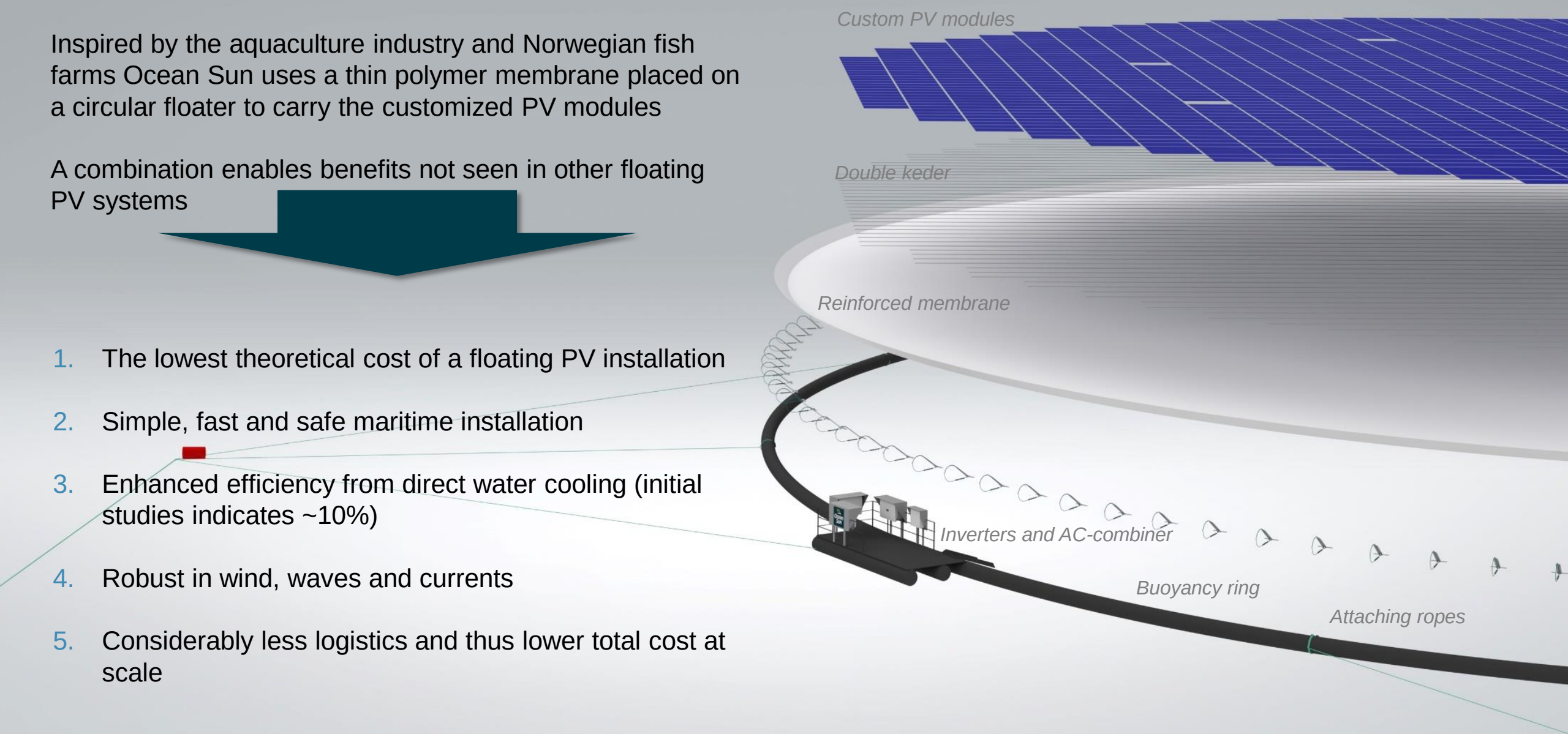
DNV·GL Power & Renewables

Benefits of the Ocean Sun technology

Inspired by the aquaculture industry and Norwegian fish farms Ocean Sun uses a thin polymer membrane placed on a circular floater to carry the customized PV modules

A combination enables benefits not seen in other floating PV systems

1. The lowest theoretical cost of a floating PV installation
2. Simple, fast and safe maritime installation
3. Enhanced efficiency from direct water cooling (initial studies indicates ~10%)
4. Robust in wind, waves and currents
5. Considerably less logistics and thus lower total cost at scale



1) Lowest theoretical cost of an FPV installation

Cost assumptions of an Ocean Sun system

- Several factors speak for the price competitiveness of the Ocean Sun system:
  - Lowest material use for required buoyancy
  - Simple and fast installation procedure
  - Ocean Sun's business model enables use of local EPC to carry out installation
  - Logistics need for the buoyancy ring is about 10x lower than for competing pontoon-based systems

- Based on quotes from previous projects, Ocean Sun has a current **BoM price (Ex-works) of around $0.50 per Wp** for a standard 74m floater

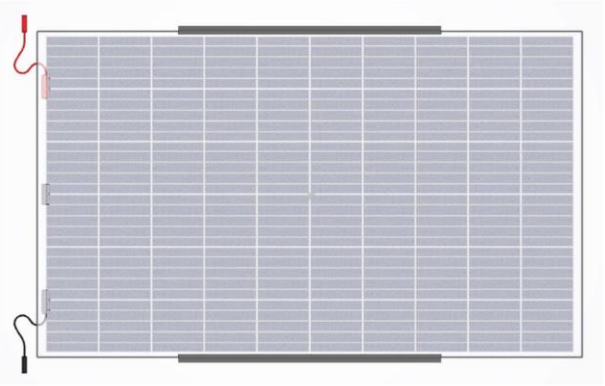
- Transportation and installation cost will vary depending on site. However, using an estimate of 30% add-on for these costs imply **total installation costs of $0.65 per Wp**.

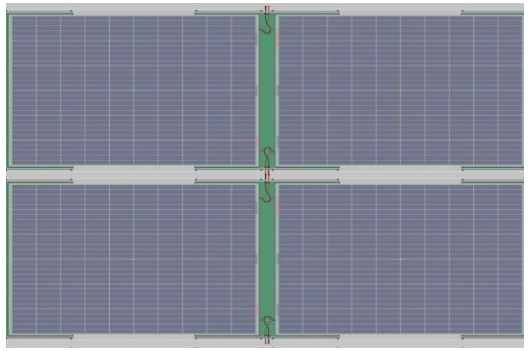
- Total material cost will be reduced further as actions to optimize the supply chain is being carried out

2) Simple, fast and safe maritime installation

Installing an OS system

- Safe and easy to perform
- Maritime installation caters for local workforce in many typical locations, no nuts and bolts
- Rapid installation of modules
- Easy to inspect if work done correctly

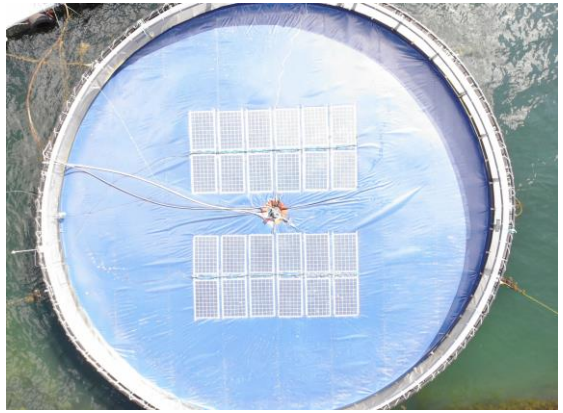


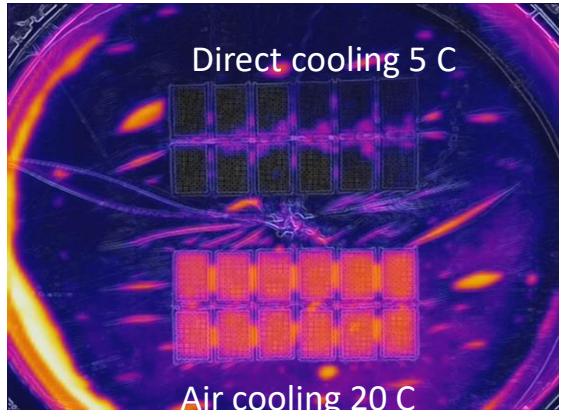


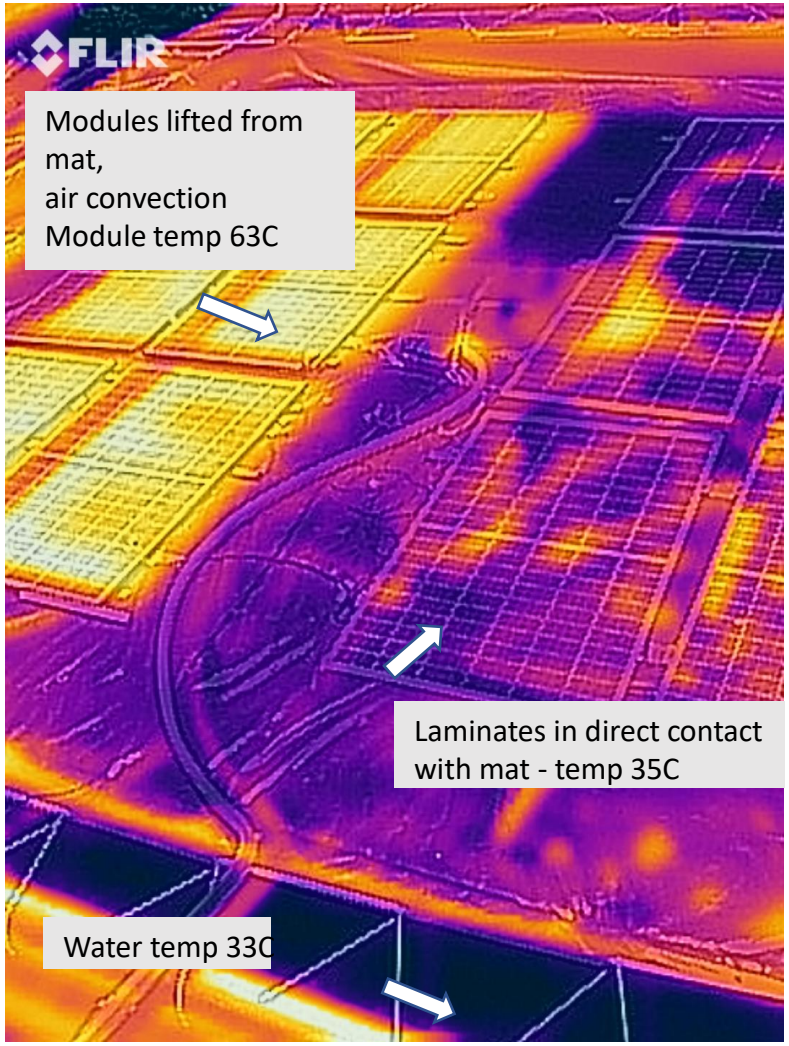
3) Enhanced efficiency from direct water cooling

PV Module temperature & efficiency

- Heat dissipation through the thin floating membrane
- Direct conduction is more effective than cooling by air convention
  - Cell temperature lowered by **28 degrees** in Singapore
  - This equals about **10 % more power**
- Energy efficiency depends on insolation and water temperature
- Thermally connected while electrically isolated
- Double glass frameless modules exhibit no PID



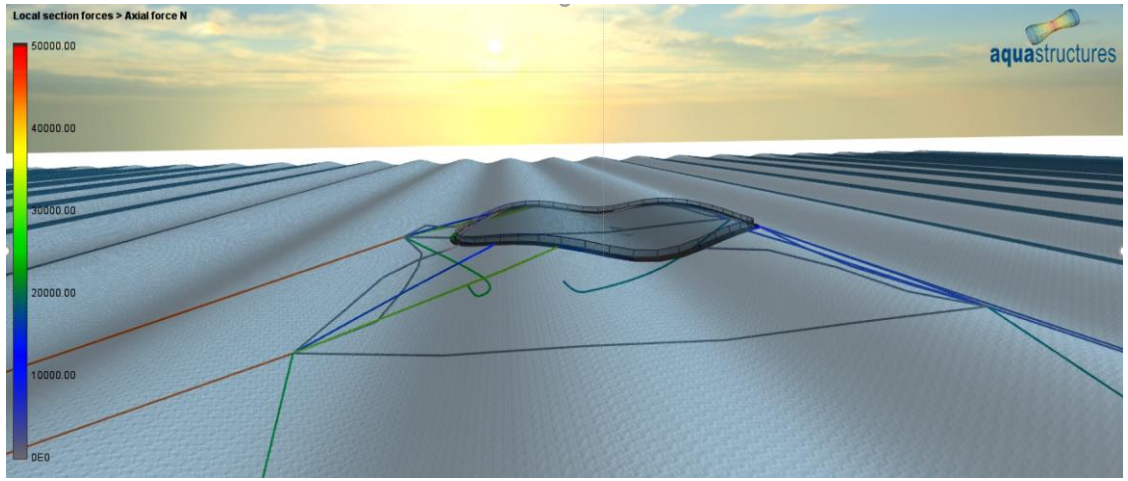


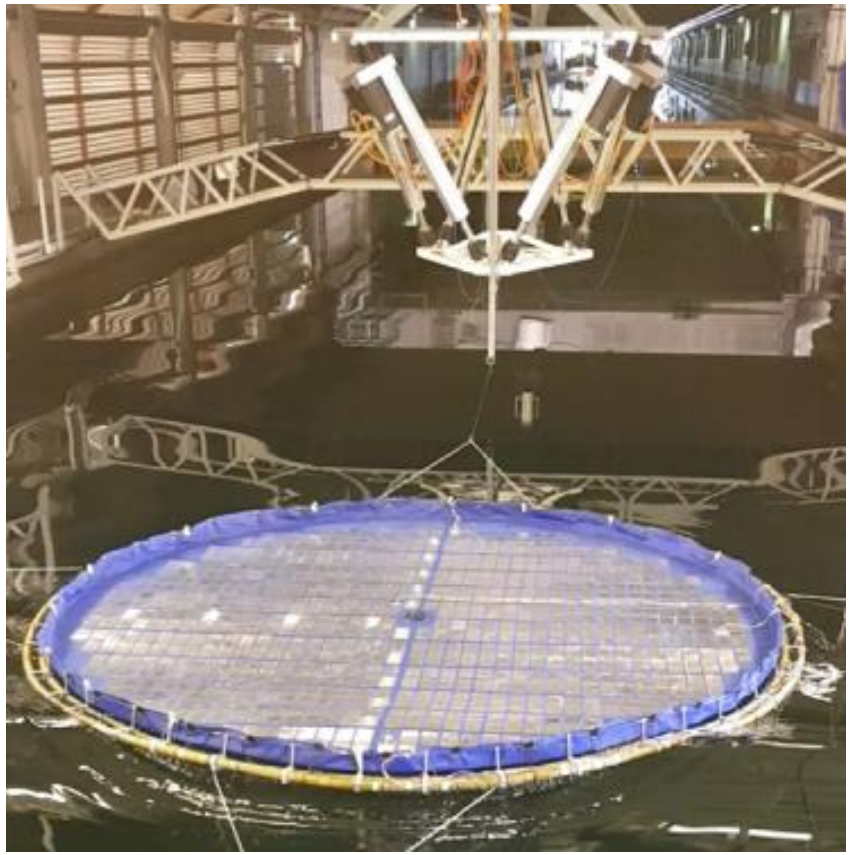


4) Robust in Wind, Waves and Currents (1/3)

Robust and proven design

- The only DNV GL reviewed FPV solution when the structural integrity is calculated according to Ocean Sun Design Premise.
- Tested at SINTEF ocean basin laboratory
- The sea is smoothed by the flexible surface membrane
- Minimal drag from sea current and wind load

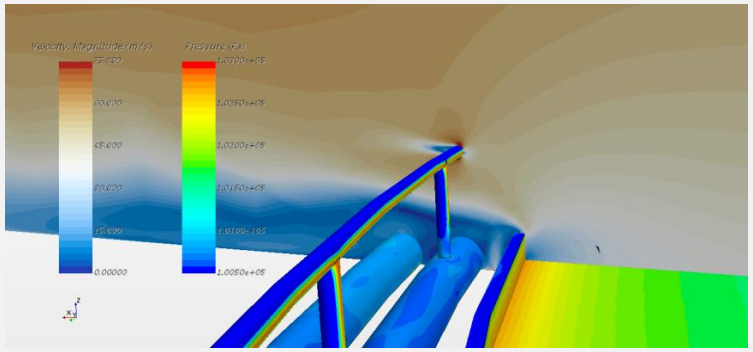




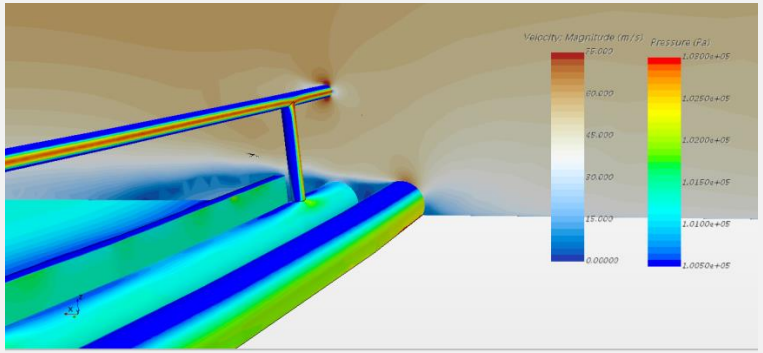
4) Robust in Wind, Waves and Currents (2/3)

Wind resistance and typhoon tolerance

- **Tested to 275 km/h winds, typhoon class 4**, with corresponding CFD analysis



Trailing edge



Leading edge

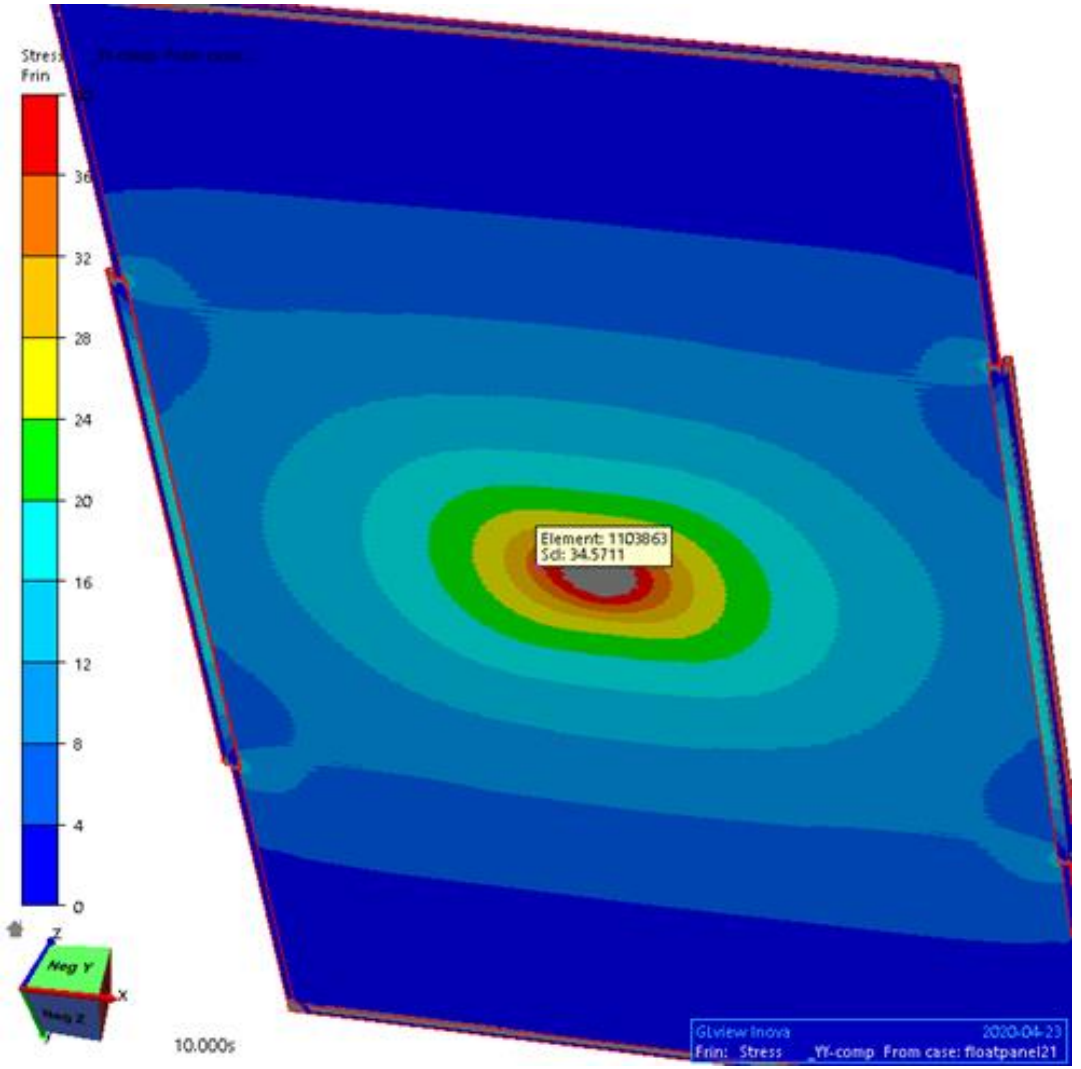
Wind Direction

- Frequent examples of conventional floating solar installations damaged by strong winds, also recent incident in Japan where system caught fire 8th September 2019 after typhoon Faxai hit w 190 km/h winds

4) Robust in Wind, Waves and Currents (3/3)

PV Module integrity & durability

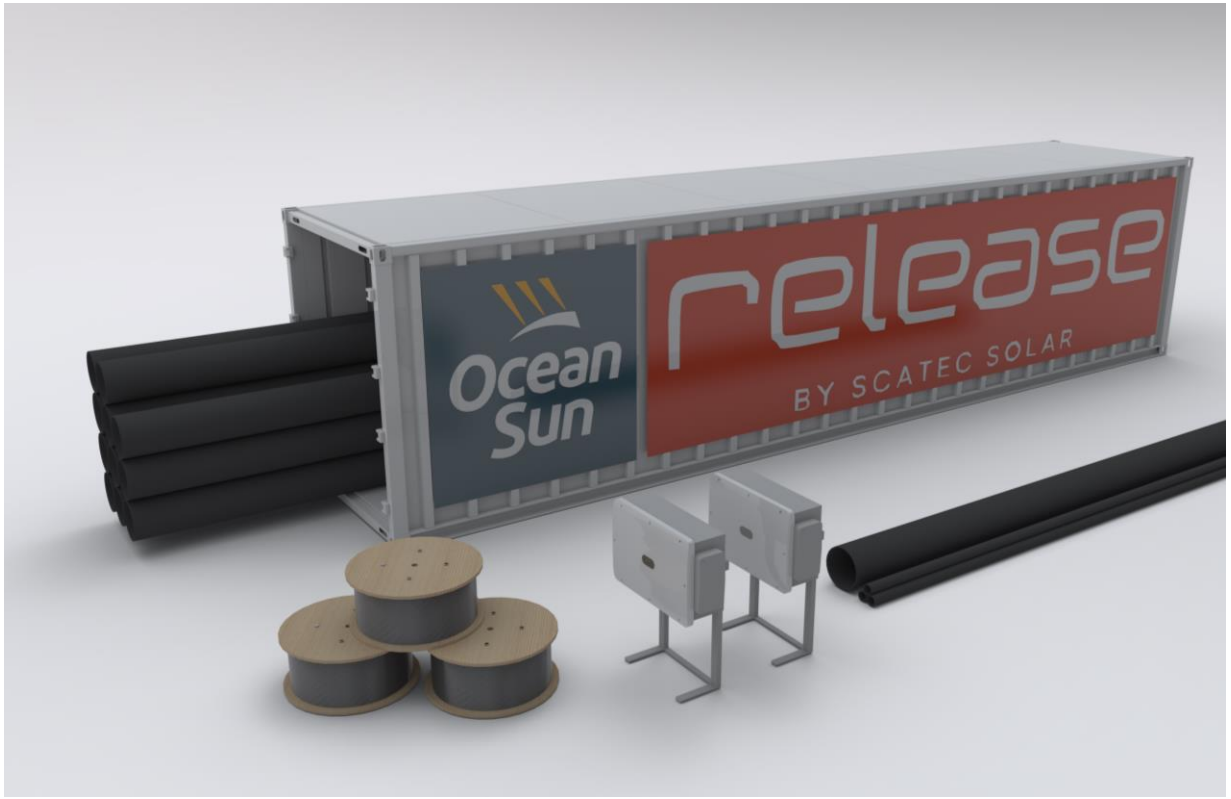
- Rigid solar module structure
- Low deflection prevents cell breakage
- Very low thermal fluctuation during day night – No thermal cycling
- Reduced thermally induced fatigue
- Data from **a system installed >3 years** ago shows that modules in Ocean Sun platform are not damaged after:
  - Years at sea with high waves
  - Being walked on during maintenance and installation



5) Considerably less logistics, less cost

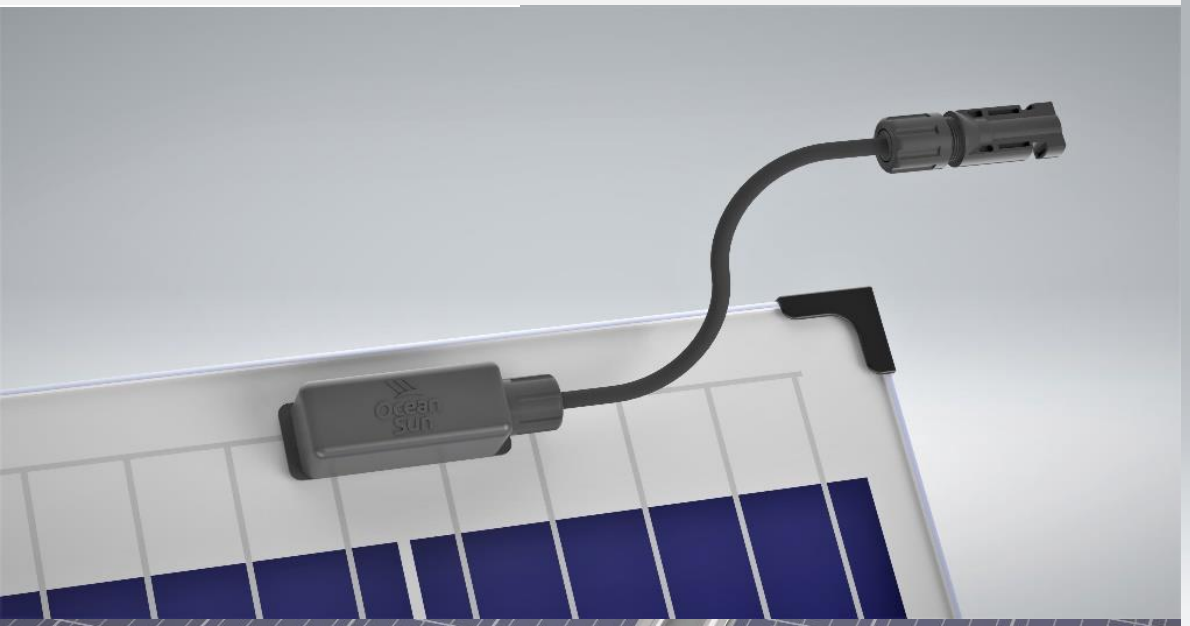
High packing density

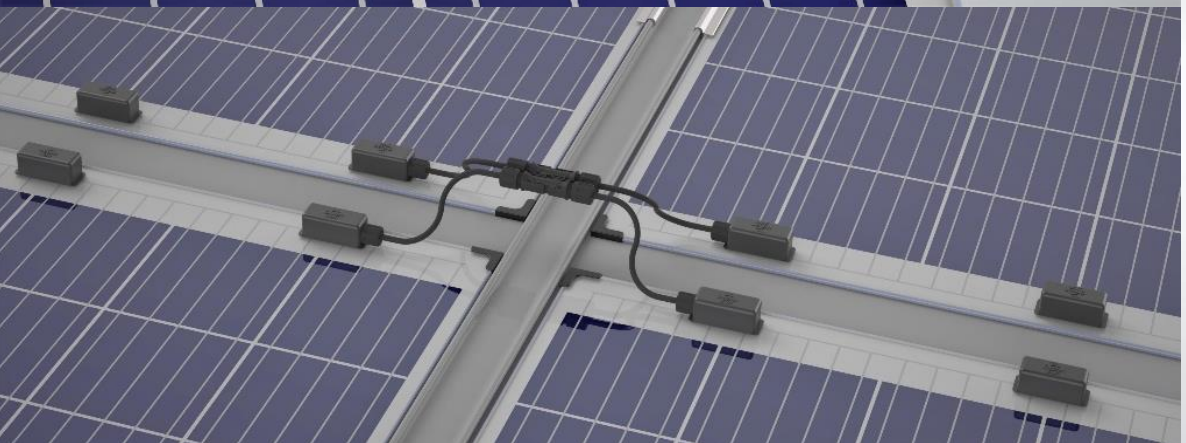
- Ocean Sun's largest floater with a membrane diameter 75 meters is designed to fit in a 40-foot container
- General PV components such as PV-Panels, inverters etc. shipped as for any system
- Overall logistics need for the buoyancy ring is about 10x lower than for competing pontoon-based systems

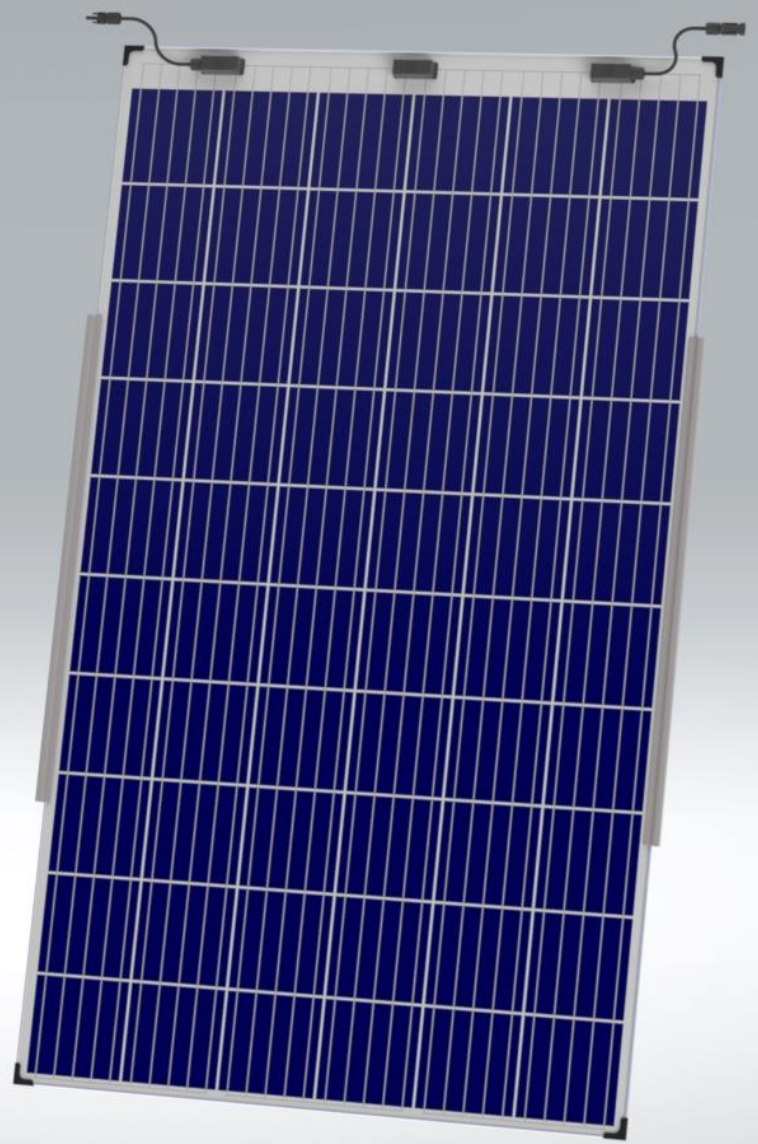


Customized Ocean Sun PV-module

Ocean Sun uses the most watertight PV module on the market developed together with GCL, with additional water ingress protection on Junction Boxes







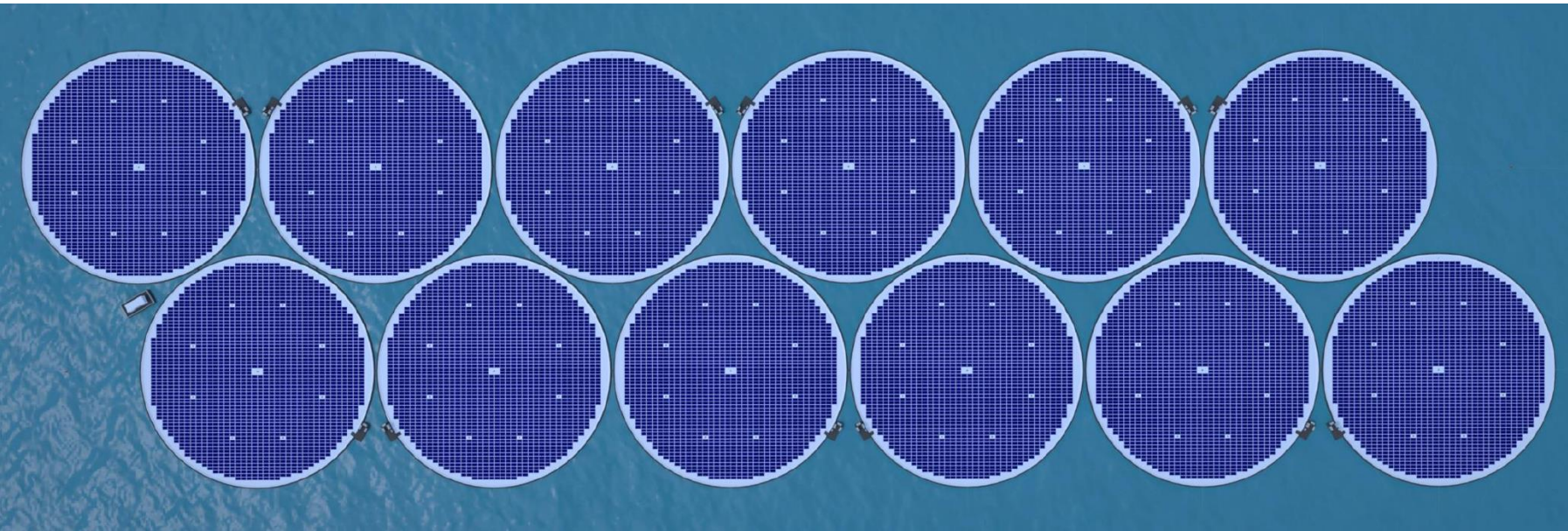
Scaling Installations - From 0,2 MWp to hundreds of MW's

Ocean Sun's standard floaters

	Diameter 73m	Diameter 51m
Capacity (Module dep.)	525-640kWp	230-260kWp
# modules	1944	848
Smart string inverters	3 x 185 kWp 1500 V DC / 800 V AC	3 x 100 kWp 1500 V DC / 400 V AC

Scalling installations

- Multi megawatt systems comprise of clusters of individual floaters with shared anchors and mooring arrangements
- Due to the robustness of the design; mooring arrangements are relatively simple and easily adapted to fit various locations with different requirements from wind, waves, currents and water level variations
- Geometries of a full project are adapted based on location and spacing between systems depends on local sea state
- Inverter stations of 3 or 6MW are placed either on land or on barges next to the floater depending on distance to shore and conditions
- Floating trafos can be used for systems with long distance to shore




VISION
WORLD LEADING TECHNOLOGY PROVIDER TO FLOATING PV SYSTEMS
THANK YOU!