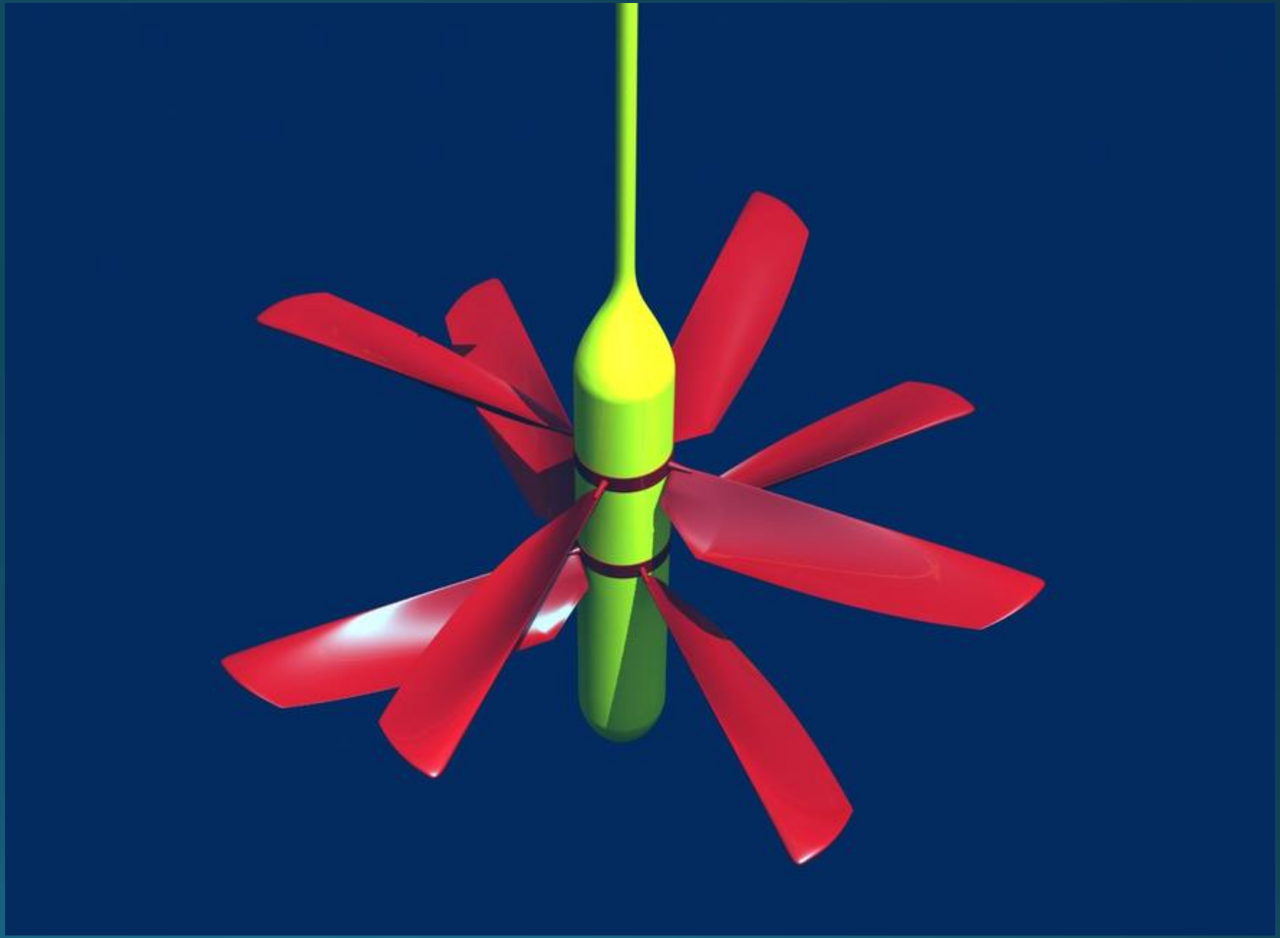
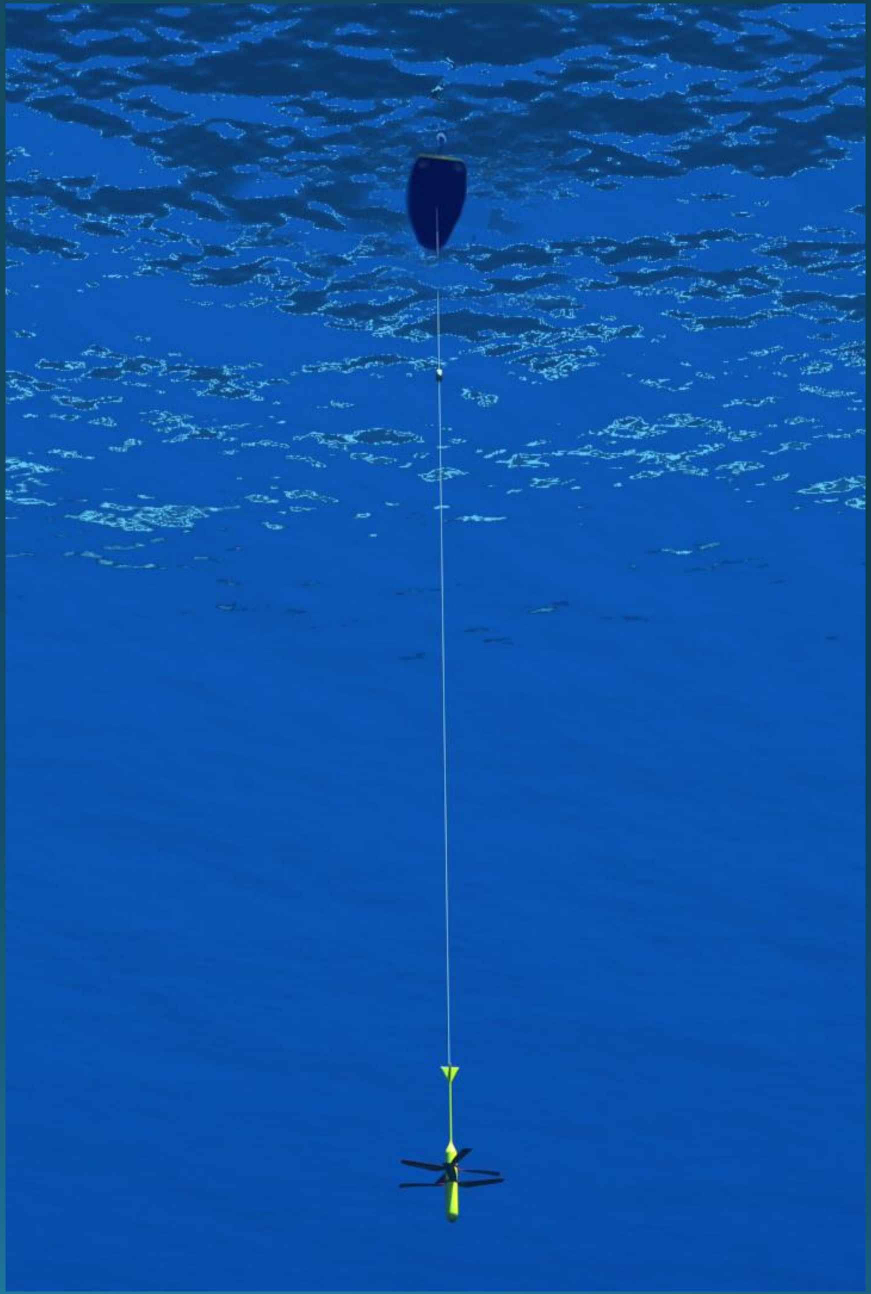
Waveco develops a patented wave energy concept, named "Subwave".

The Subwave Concept

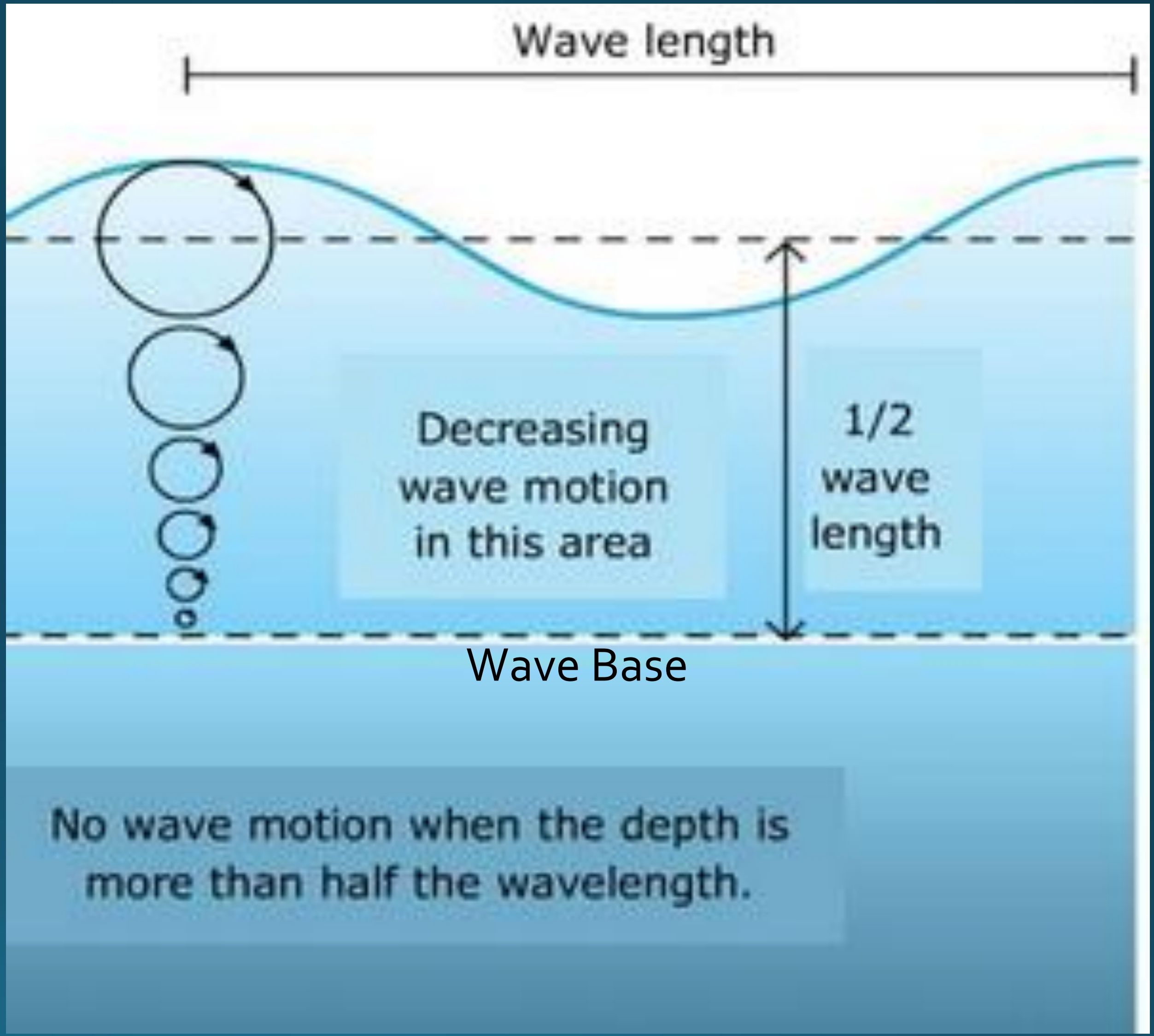
The idea is a vertical water mill with two counterrotating rotors, hanging…



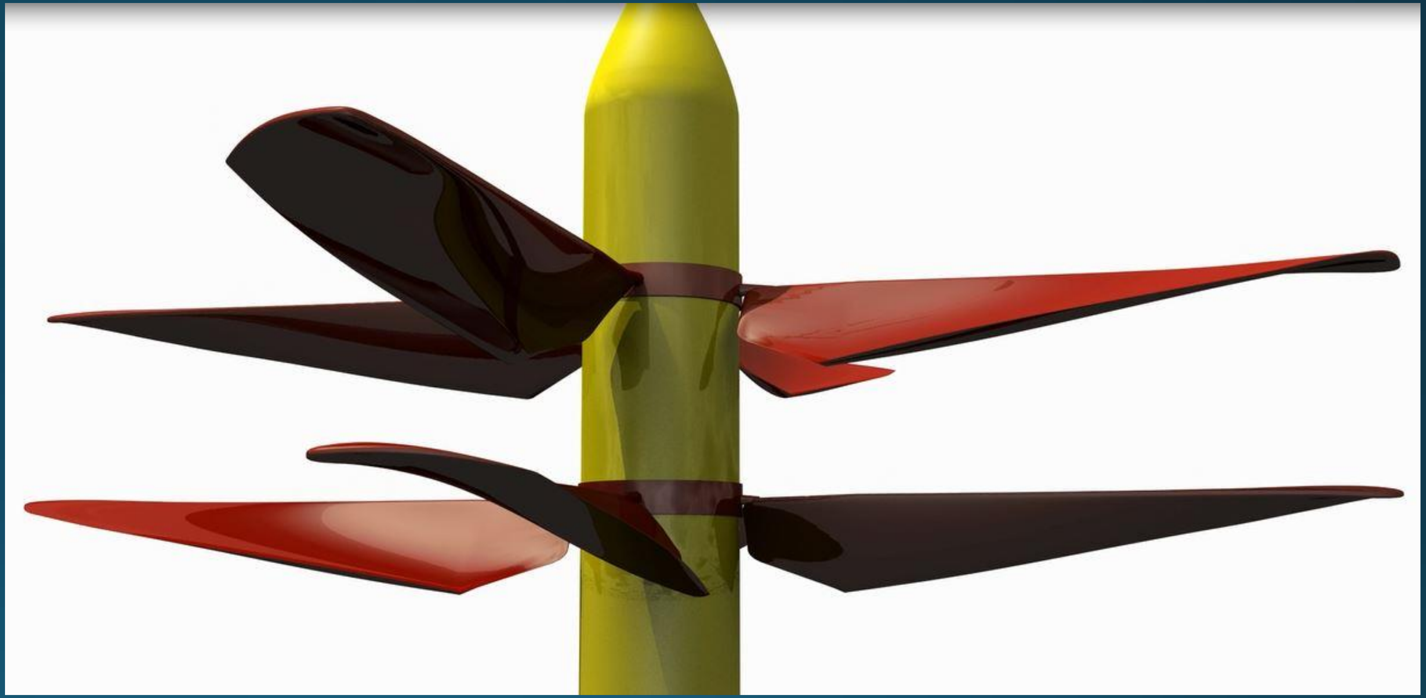
…from a buoy floating on the surface.



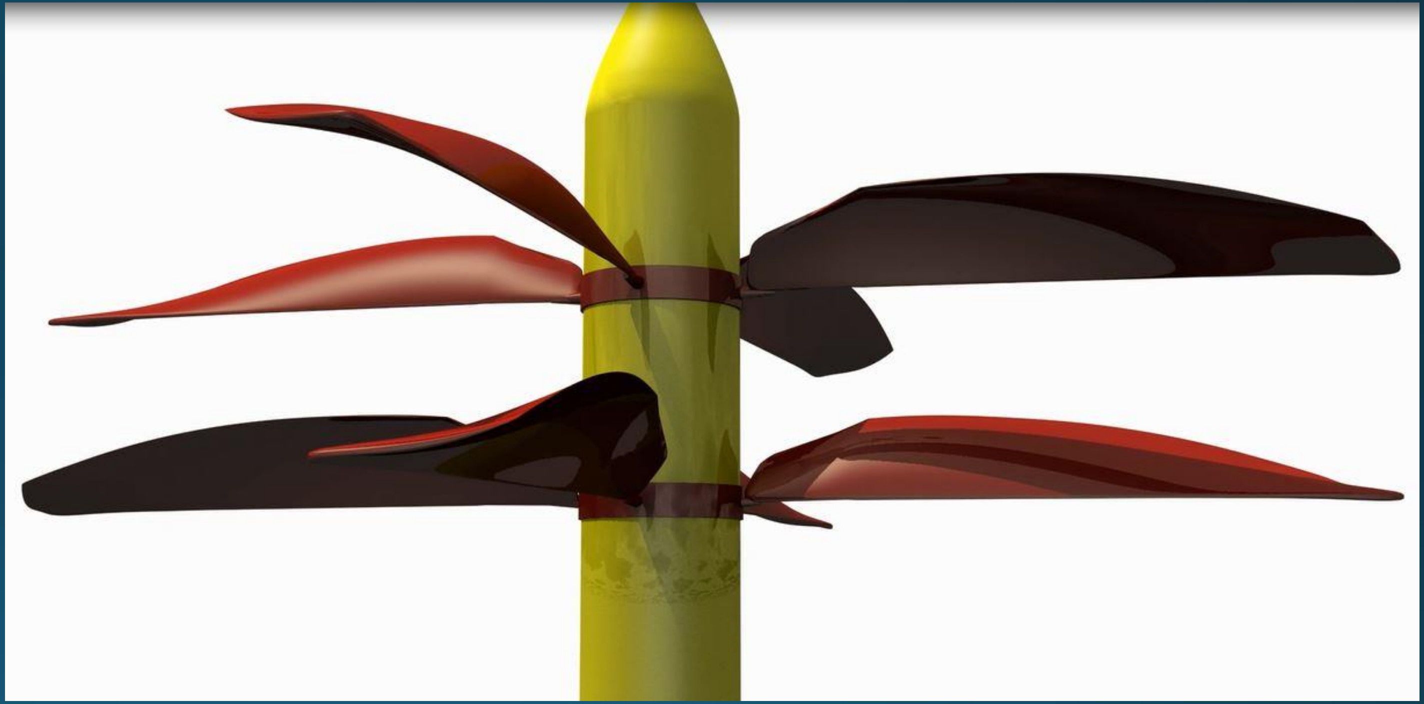
It hangs so deep that it comes under the wave base.



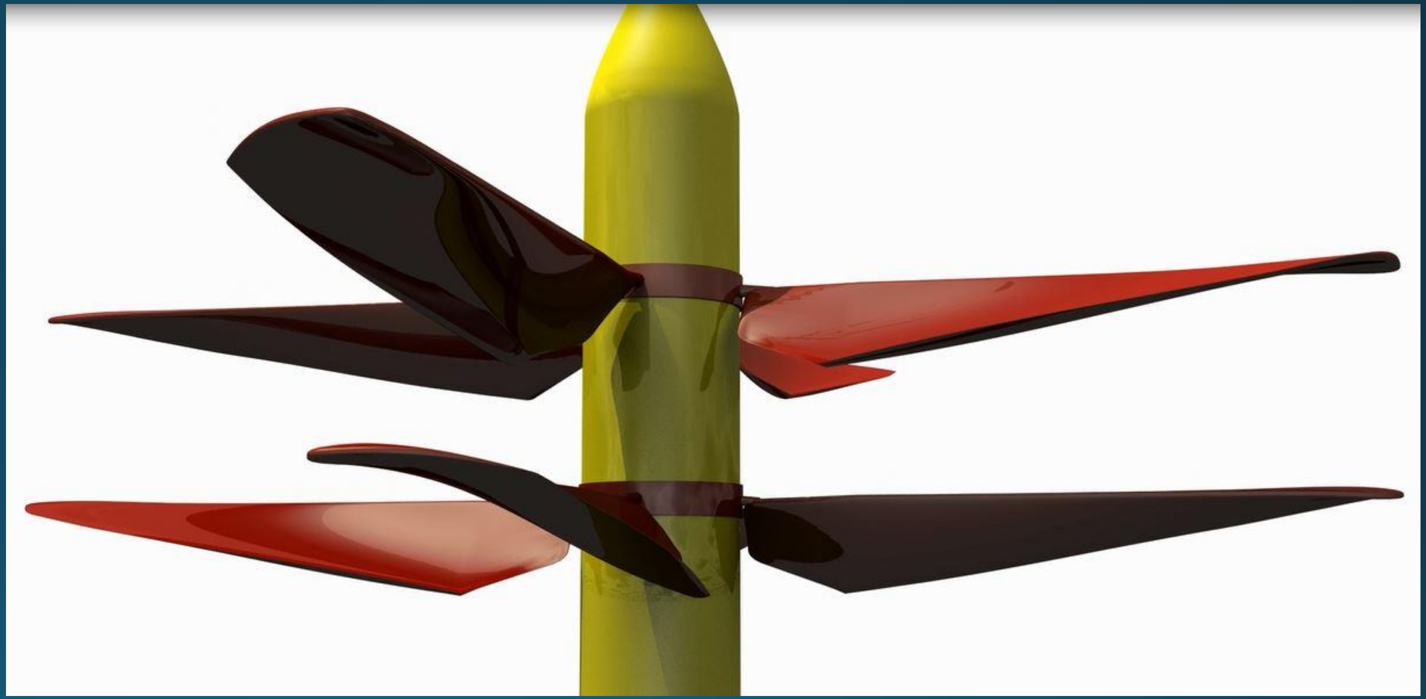
When ocean waves affect the buoy, the turbine will be alternately pulled up …



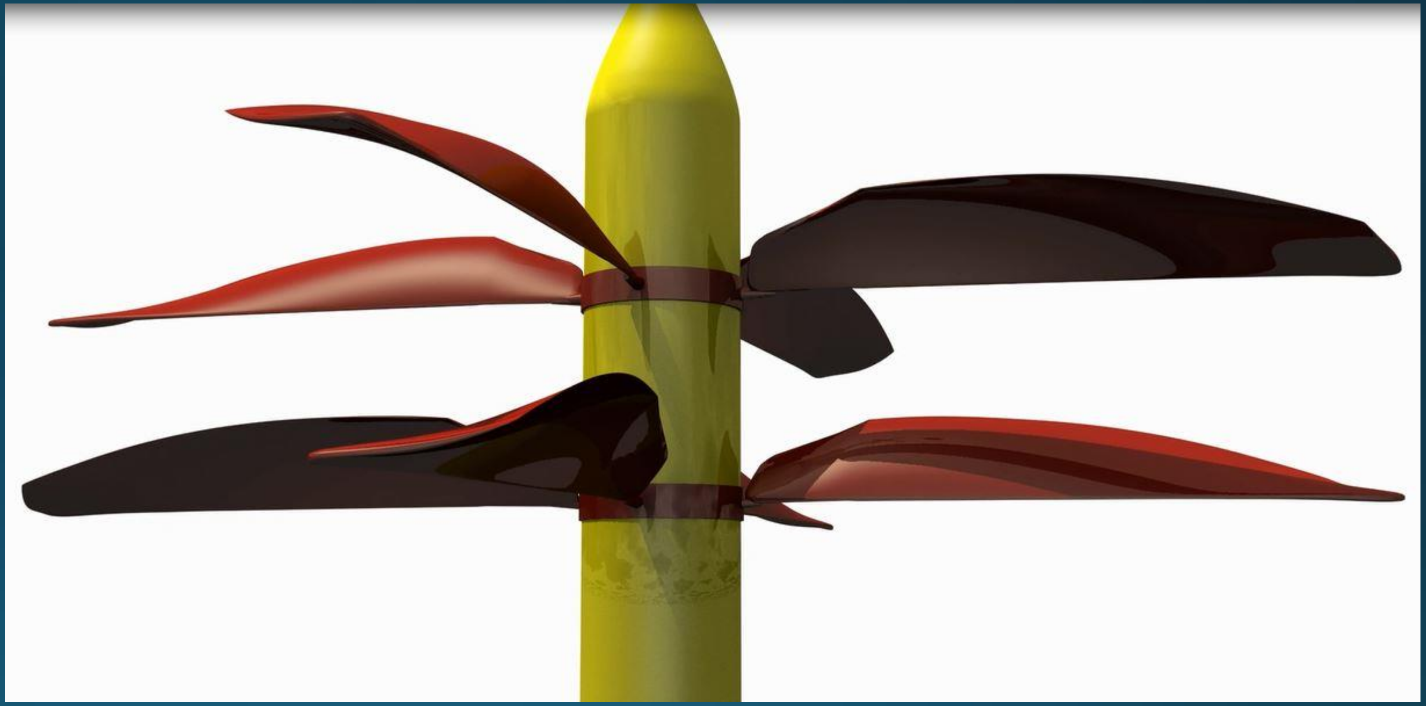
... and sinking down in the body of water.



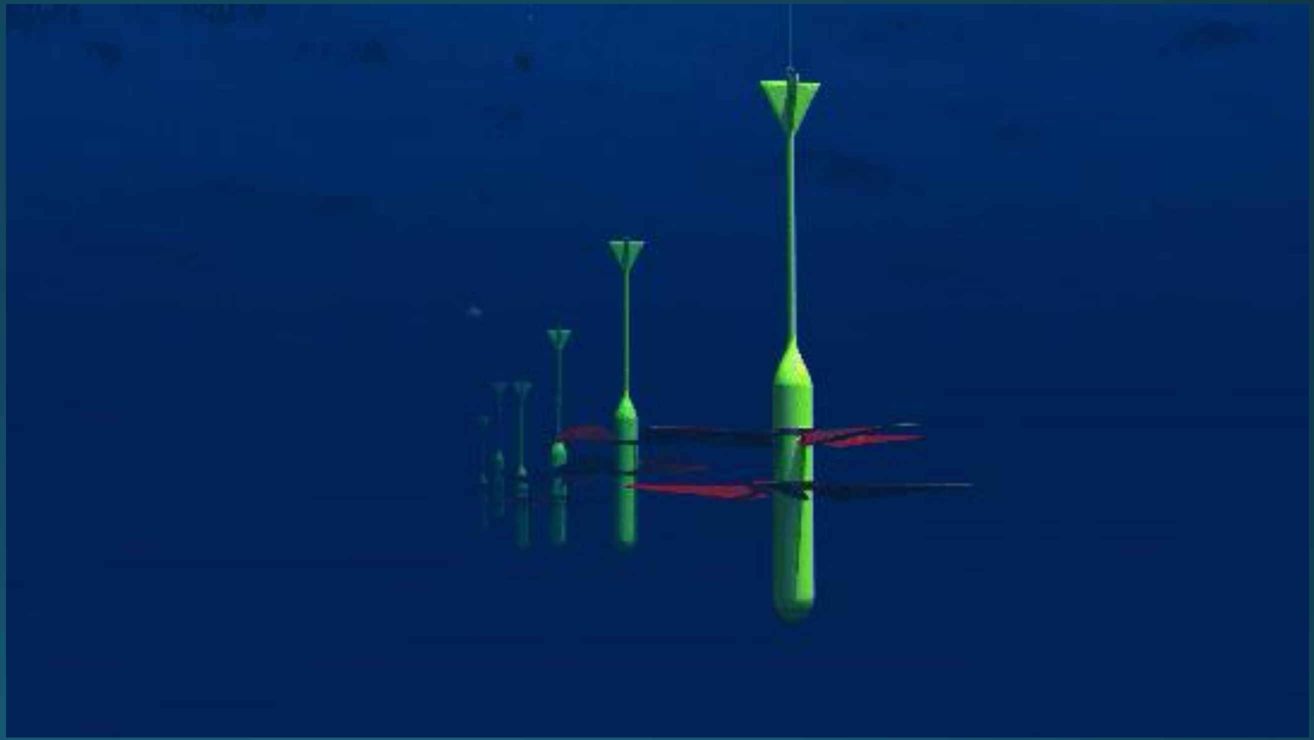
The turbine blades are made of a flexible material …



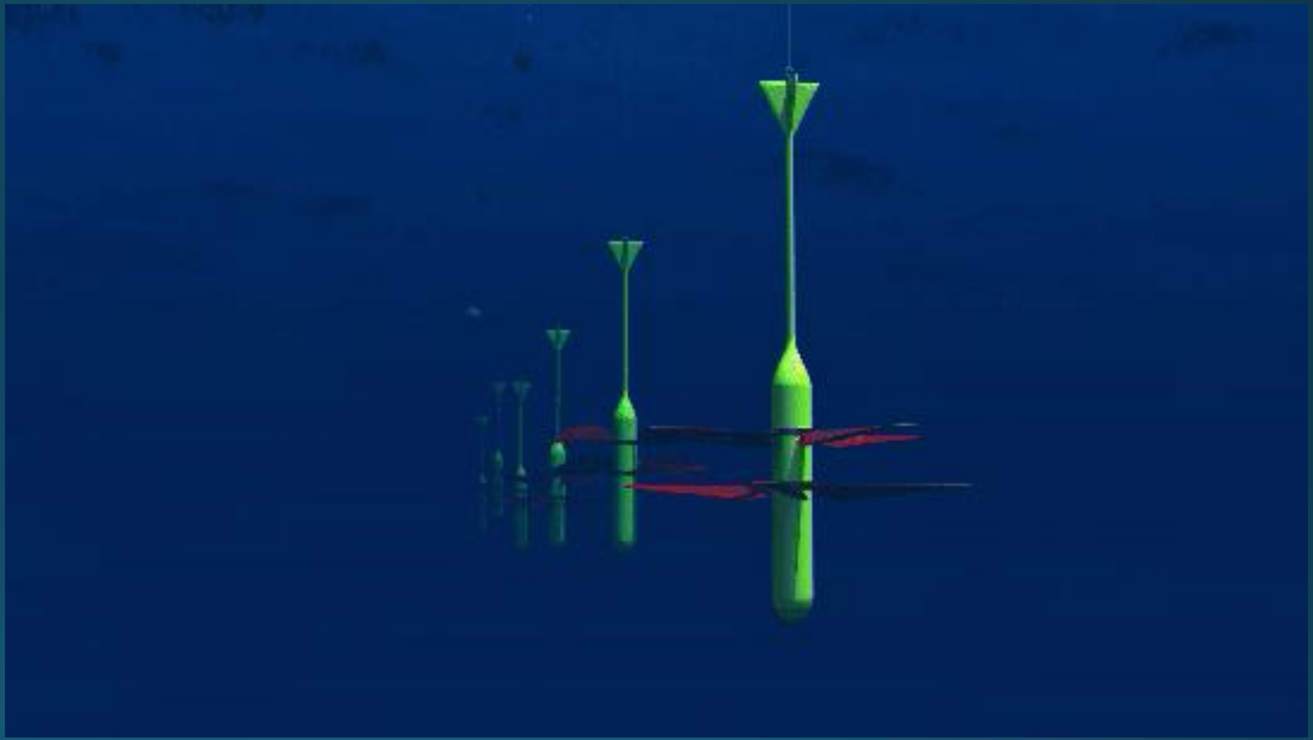
… and mounted so that they rotate the same way whether the turbine is going up or down in the water.



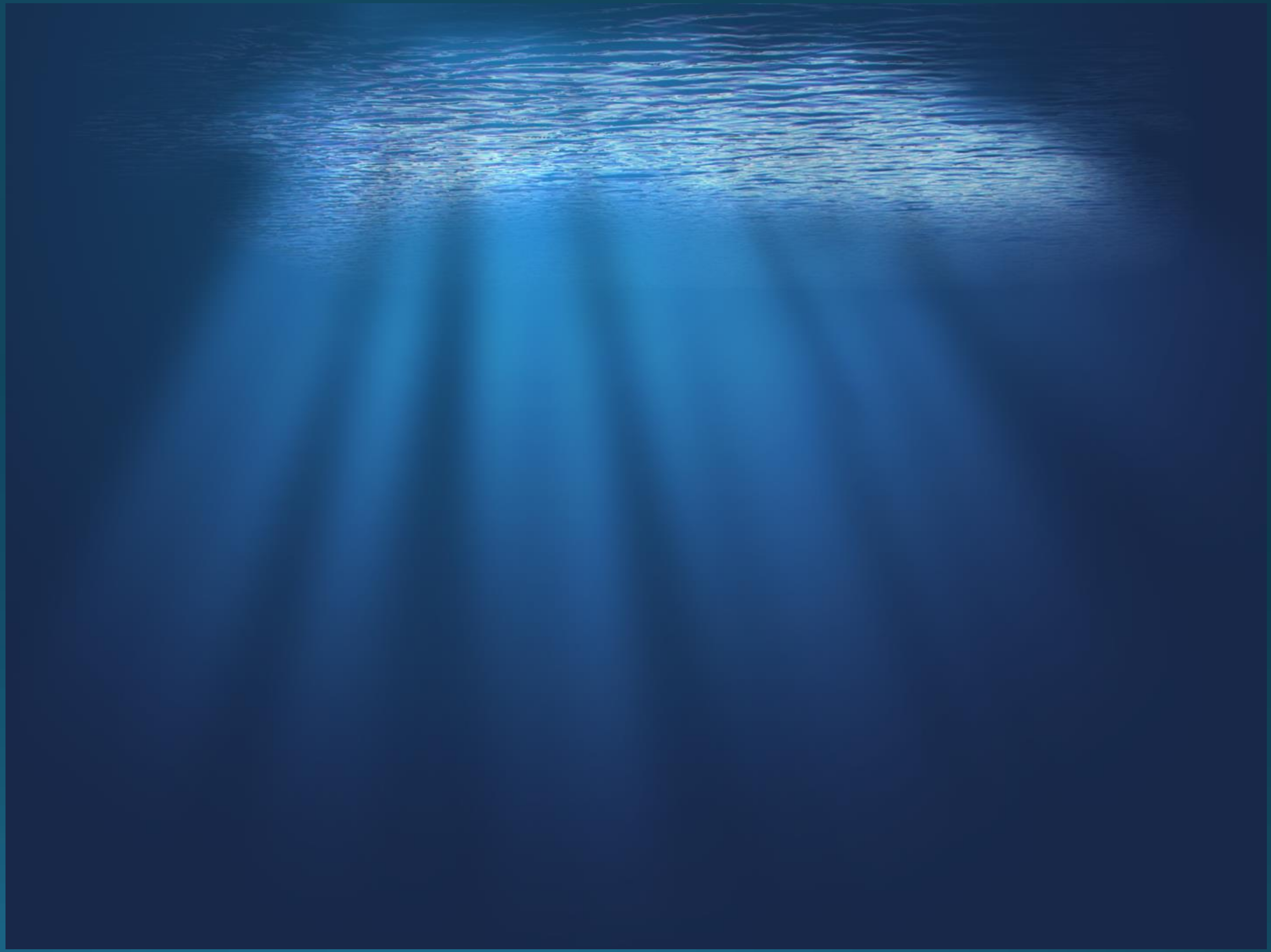
Like this.



The Subwave concept has several advantages.

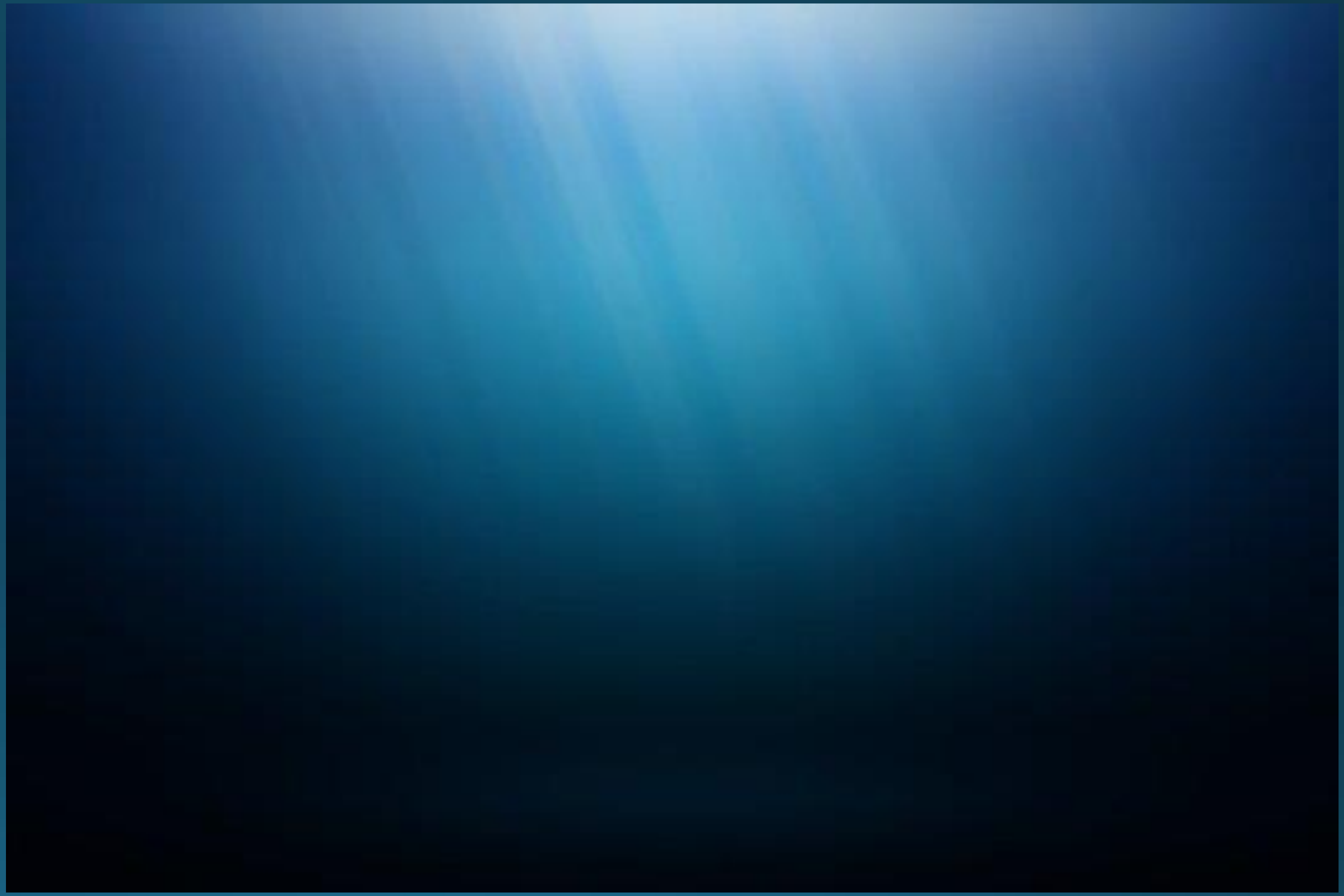


The turbine is in the calm and dark water in the depth,…



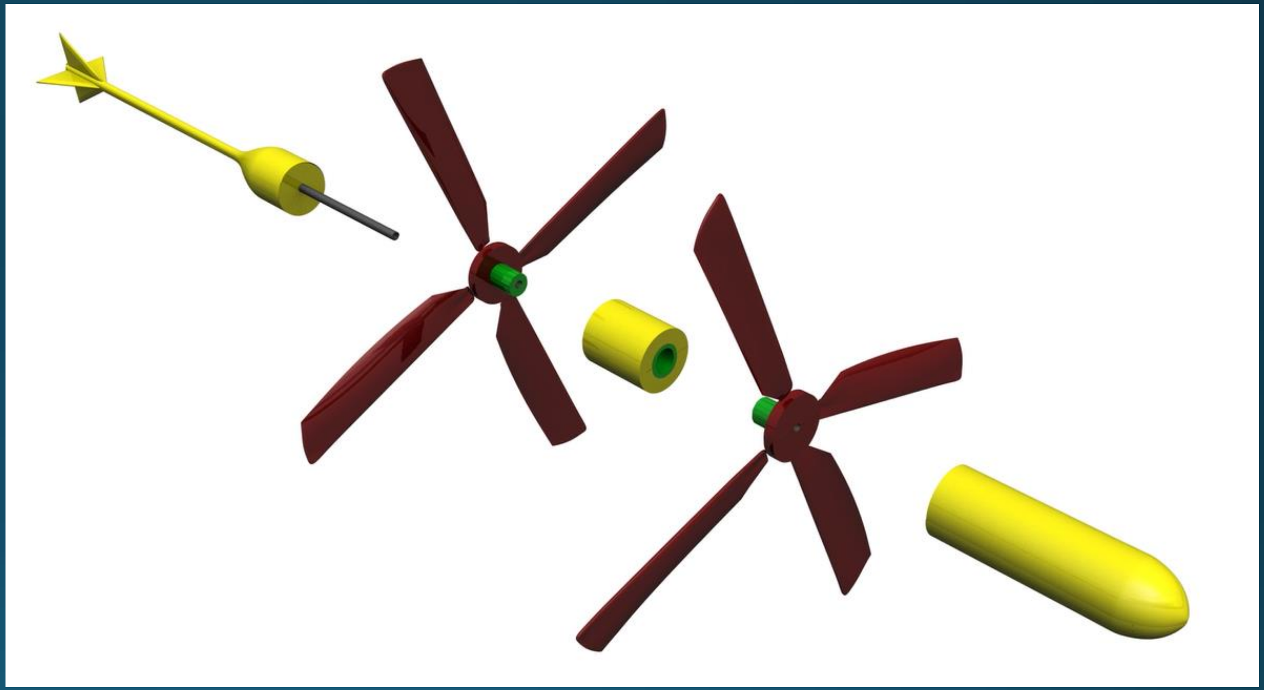
… shielded from the beatings on the surface.

Lack of sunlight will restrict marine growth.

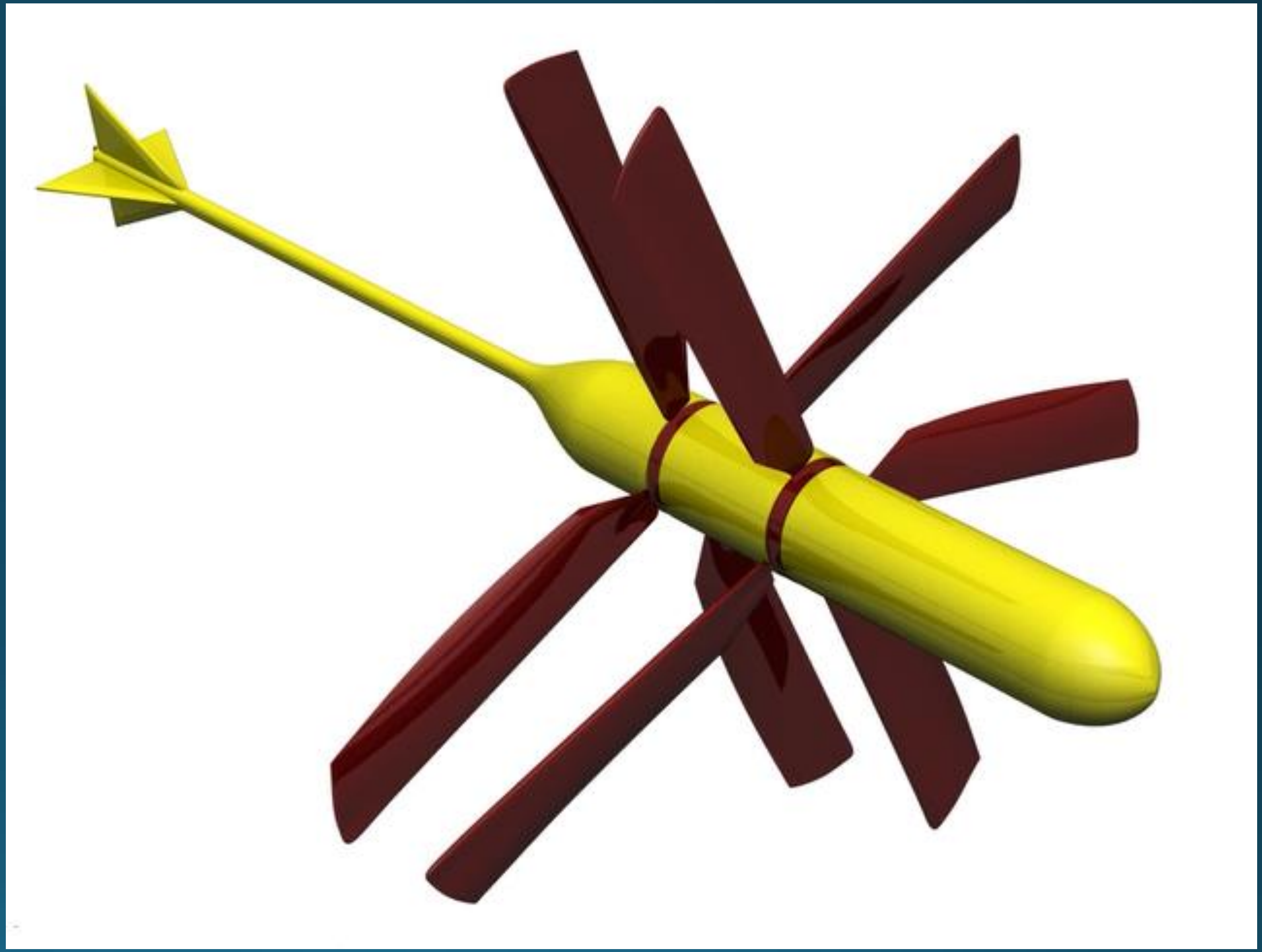


The system has no end-stop and will work in any wave height.

Mechanically it is very simple.

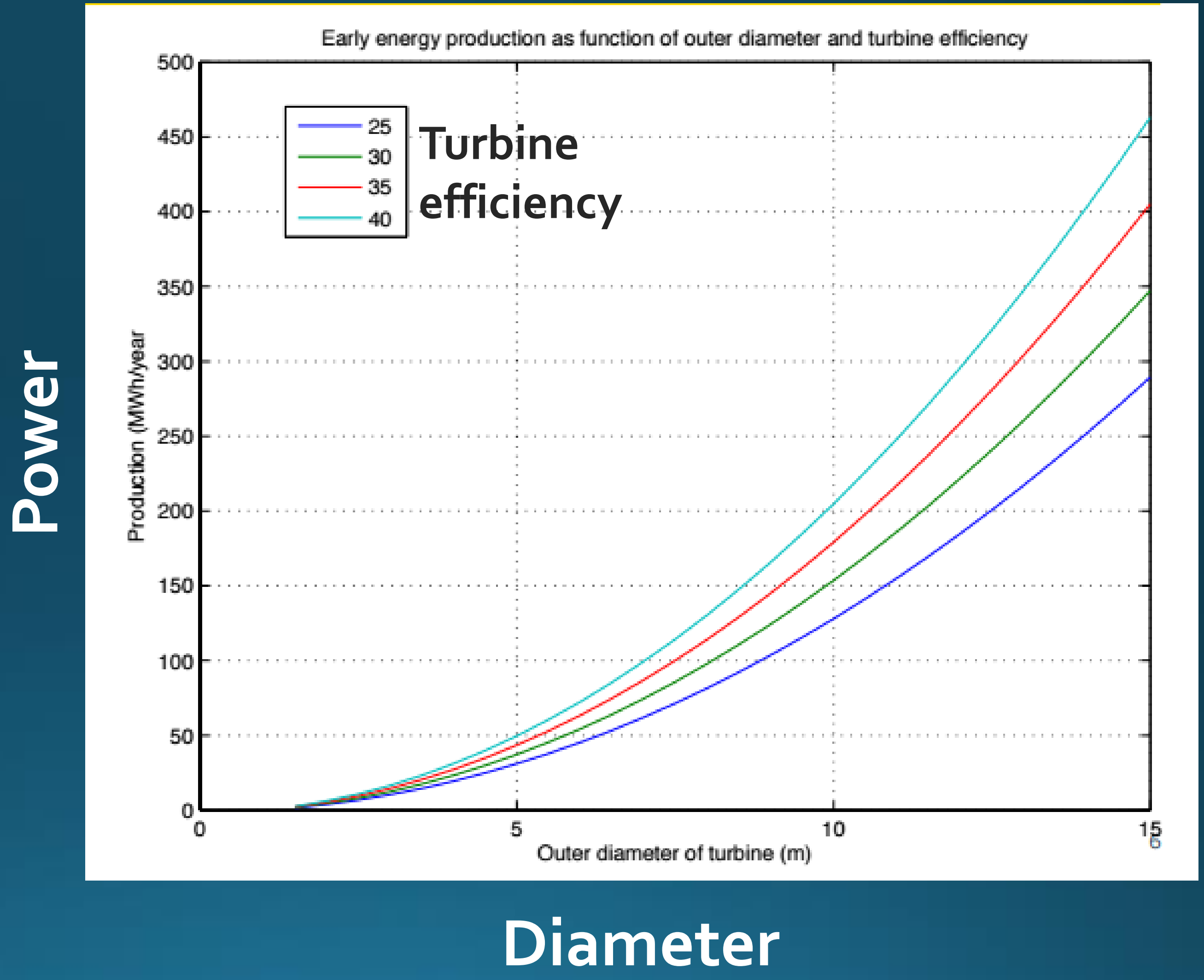


The material consumption is low in relation to the power potential, ...

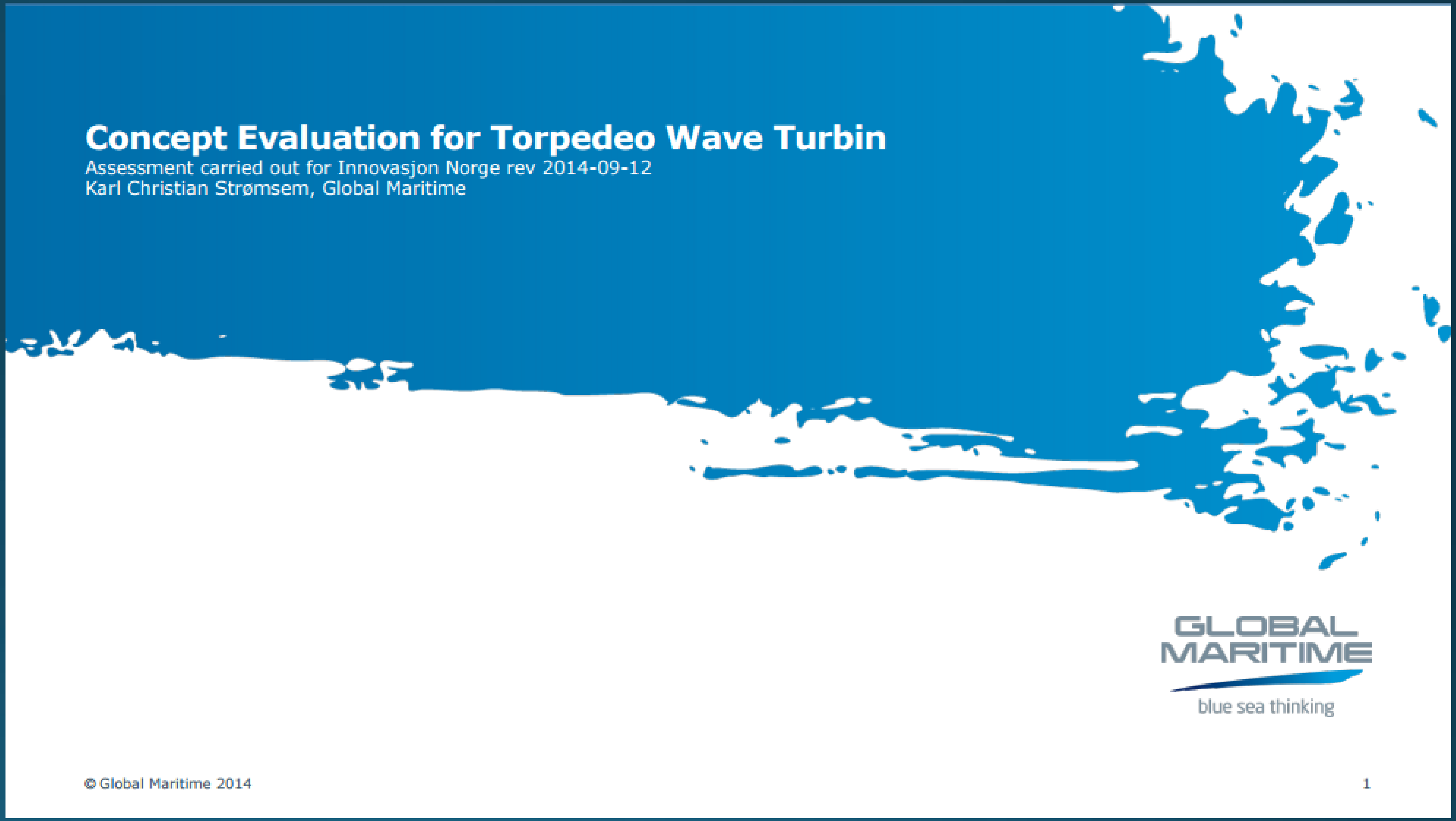


... which increases with the square of the length of the turbine blades.

Just like wind turbines.



The concept has been through a professional theoretical assessment …


Concept Evaluation for Torpedeo Wave Turbin

Assessment carried out for Innovasjon Norge rev 2014-09-12

Karl Christian Strømsem, Global Maritime

GLOBAL MARITIME

blue sea thinking

… with power production estimates.

Performance summary

GLOBAL MARITIME

Performance as function of turbine size					
Diameter of turbine	(m)	2	6	**10**	15
Blade length	(m)	1	3	**5**	7.5
Surface Buoy Diameter	(m)	2.0	6.8	**11.5**	17.3
Energy Capture Ratio	(%)	2.5%	8.6%	**14.4%**	21.7%
Total Yearly production	(MWh)	5	54	**154**	347
Yearly production value UK	(1000 kr)	9	109	**307**	695
Yearly production value NO	(1000 kr)	4	49	**138**	313
Income over 10 Year (UK)	(mill kr)	0.1	1.1	**3.1**	6.9
Income over 10 Year NO	(mill kr)	0.0	0.5	**1.4**	3.1

The table show the energy production, and potential earnings as a function of the turbine diameter. The surface buoy size (diameter) is derived as a function of the size of the turbine.

It is shown that the small diameter turbine indicated in the drawing and and animation received is not an ideal configuration of the system.

We see that larger the turbine blades improve the energy capture efficiency (from 2.5 % to 21.7 % in the examples shown here) and hence dramatically improves the energy production.

From the figure of energy production we see that the output is an exponential function of the turbine size. This calls for a larger turbine. The larger the better performance.

The size of the turbine will need to be balanced against the cost of the turbine which we have not been able to do in this small study. This will have to be an important part of the eventual development of the final system.

From the table we see that a turbine with blade lengths 5 meters will typically produce 154 MWh pr year in a Karmøy environment which in the UK support regime can give an income of 3.1 MNOK over a 10 year period.

In a more exposed location the production will be higher.

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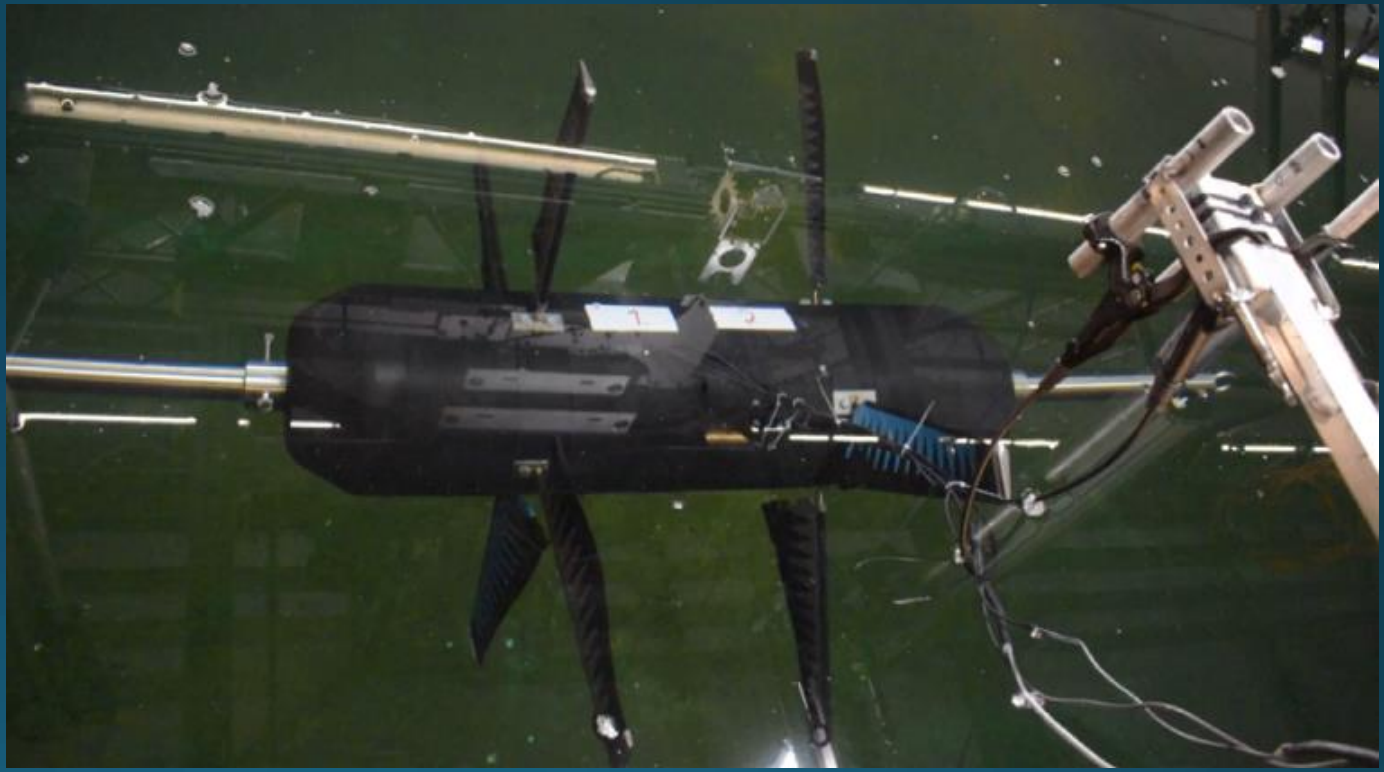
In a more exposed location the production will be higher.

The production value estimates are made in 2014.

We have made a one-meter model …

… and investigated in a towing tank, horizontally, …



… the relationship between pulling power and power output for different towing speeds.

Brakes on the rotors simulated the effect of a generator.

Pulling Power, measured in Watts (W)

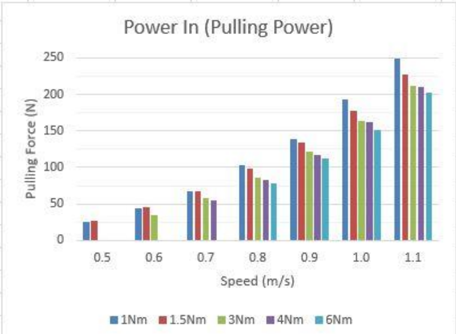
	Test 1	Test 2	Test 3	Test 4	Test 5
m/s	1Nm	1.5Nm	3Nm	4Nm	6Nm
0.5	25	27			
0.6	44	45	35		
0.7	67	67	58	55	
0.8	103	98	85	83	78
0.9	138	134	121	117	112
1.0	194	177	164	161	152
1.1	249	228	211	210	202

Combined Power output (turbine 1 + turbine 2)

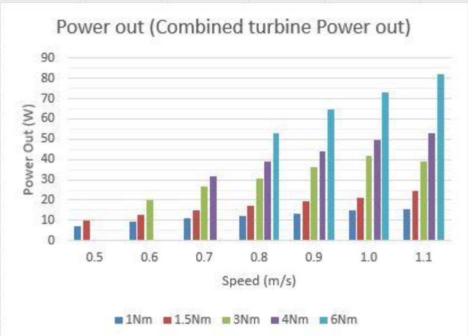
	Test 1	Test 2	Test 3	Test 4	Test 5
m/s	1Nm	1.5Nm	3Nm	4Nm	6Nm
0.5	7	10			
0.6	9	13	20		
0.7	11	15	27	32	
0.8	12	17	31	39	53
0.9	13	19	36	44	65
1.0	15	21	42	50	73
1.1	15	25	39	53	82

Efficiencies

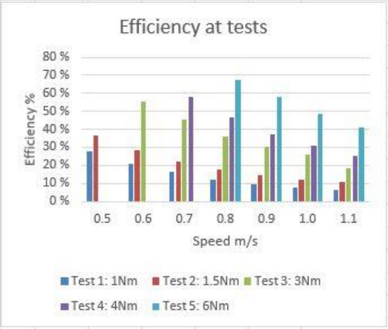
	Test 1:	Test 2:	Test 3:	Test 4:	Test 5:
m/s	1Nm	1.5Nm	3Nm	4Nm	6Nm
0.5	28 %	36 %			
0.6	21 %	28 %	56 %		
0.7	16 %	22 %	45 %	58 %	
0.8	12 %	17 %	36 %	47 %	68 %
0.9	10 %	14 %	30 %	37 %	58 %
1.0	8 %	12 %	26 %	31 %	48 %
1.1	6 %	11 %	18 %	25 %	41 %



Pulling power



Power output



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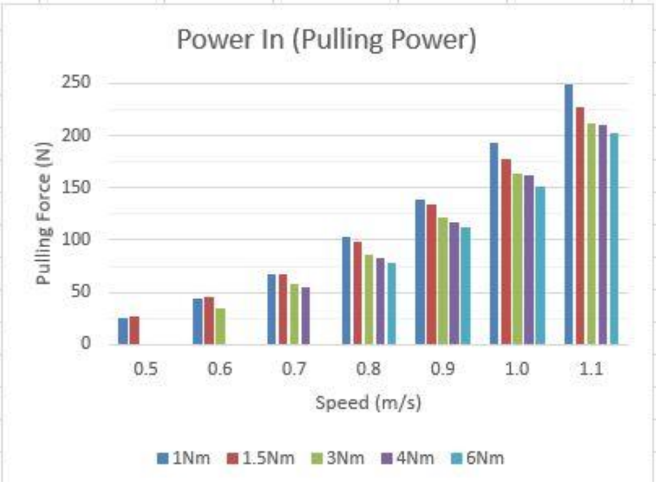
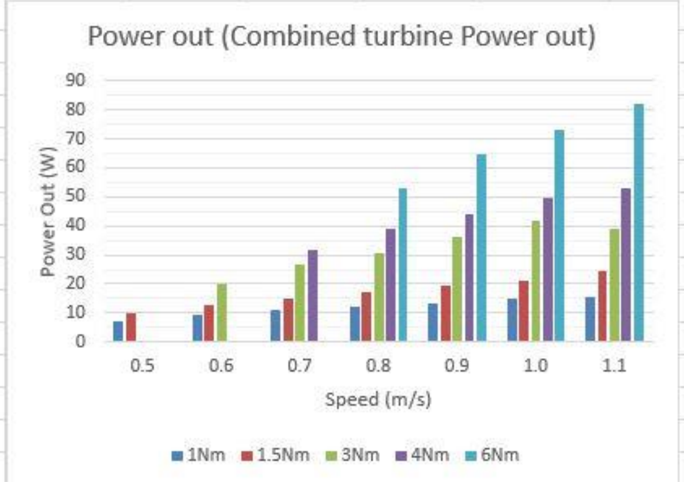
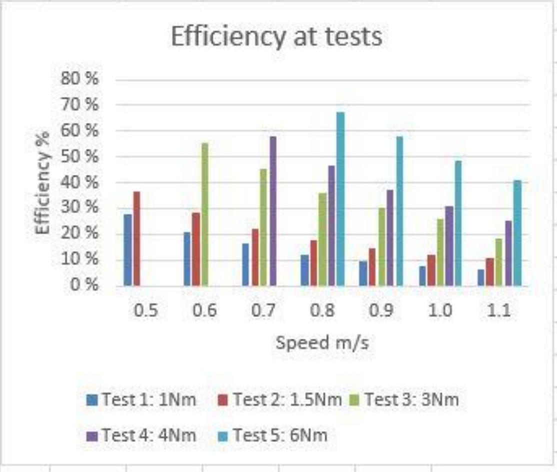






We found, surprisingly, that the pulling power went down when the breaking force on the rotors went up.

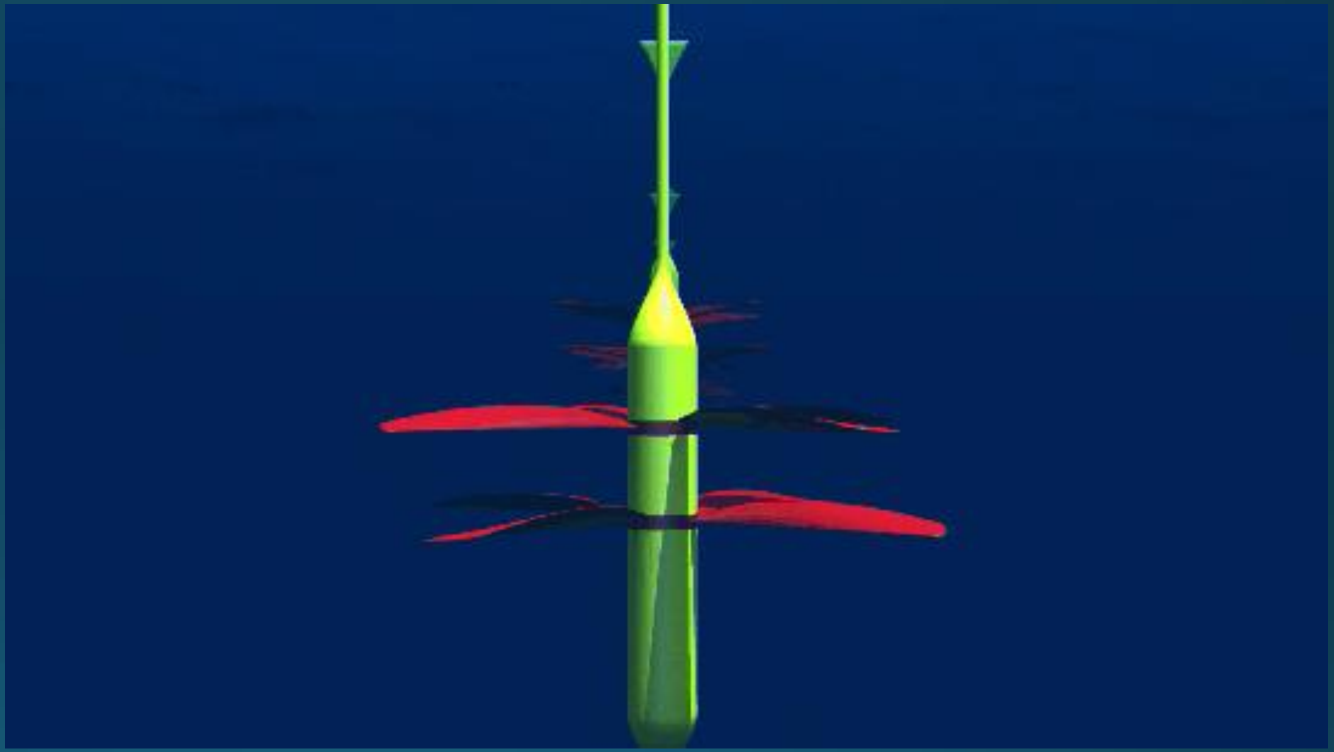
The power output went up when the breaking force went up, as expected.

The efficiency was therefore highest when the rotational speed of the wings was low.

This seems to imply that the two generators, one for each rotor, should variably load the rotors so that they rotate slowly and at the same speed for all vertical turbine speeds through water.

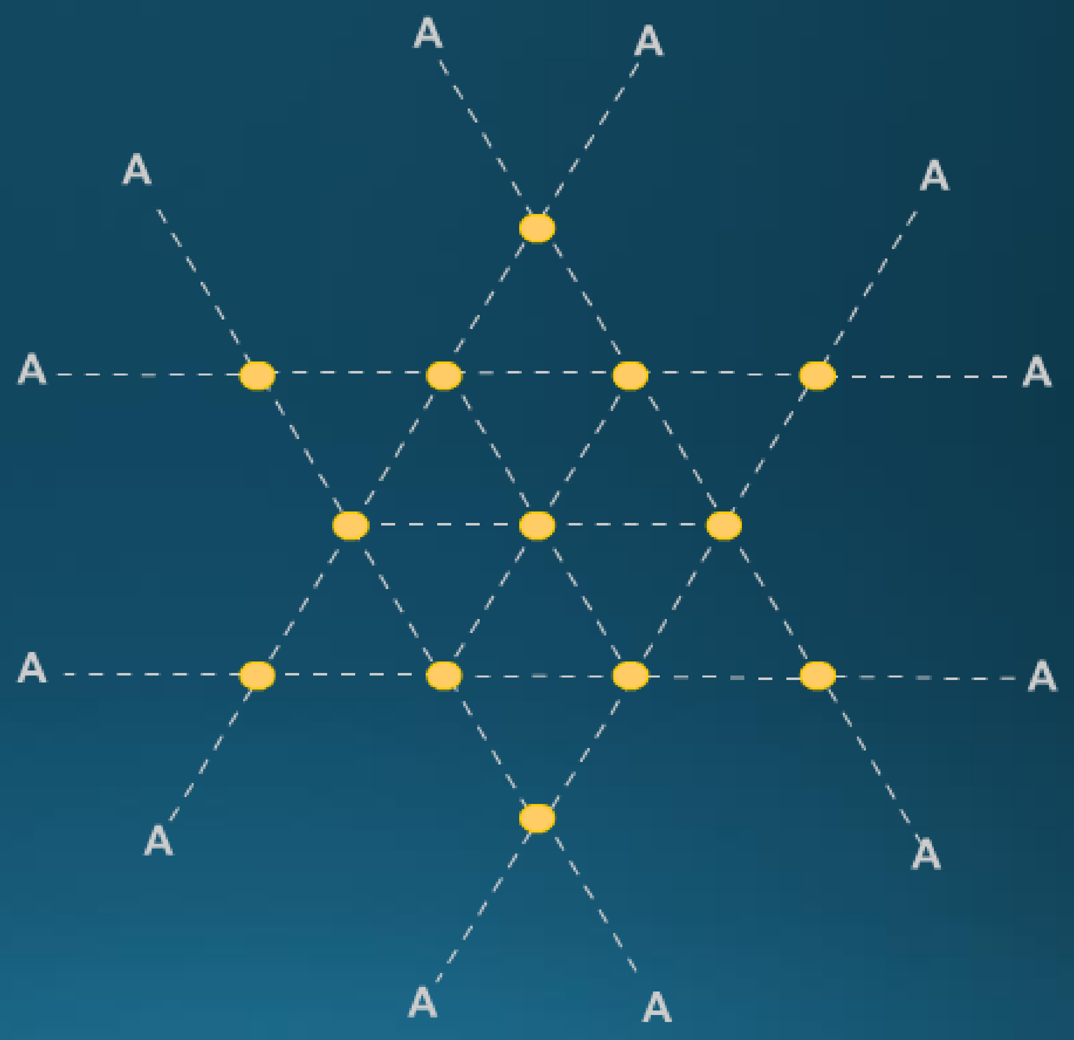
The vertical turbine speed through water will, of course, vary constantly between zero and max, two times for each wave.

This is therefore a very important point.

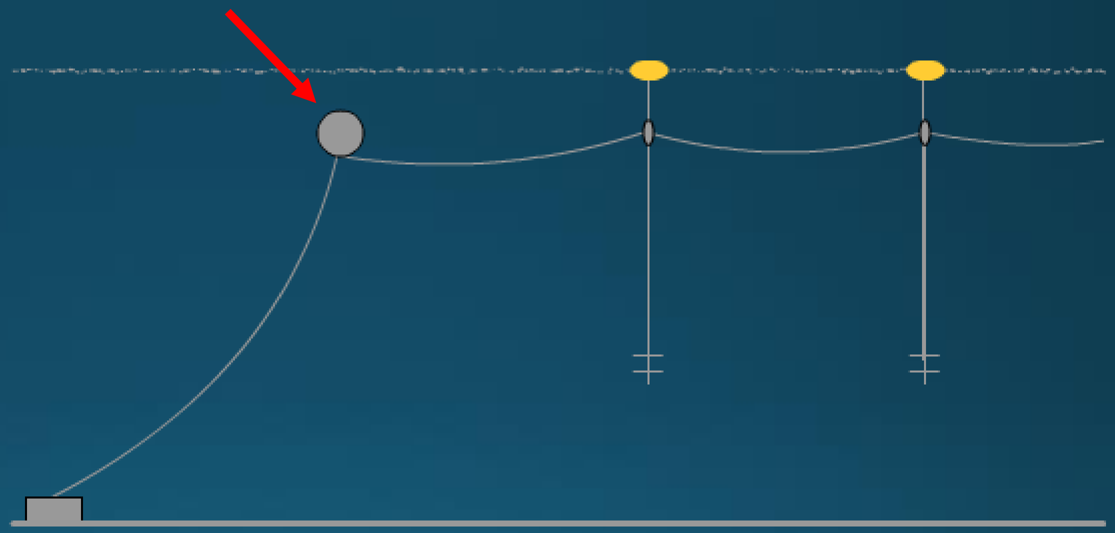


Arrays

Turbines will not operate alone but in arrays. Mooring is costly. We will use fewer anchors by arranging the units in groups. Here 13 units are moored with 12 anchors (A).



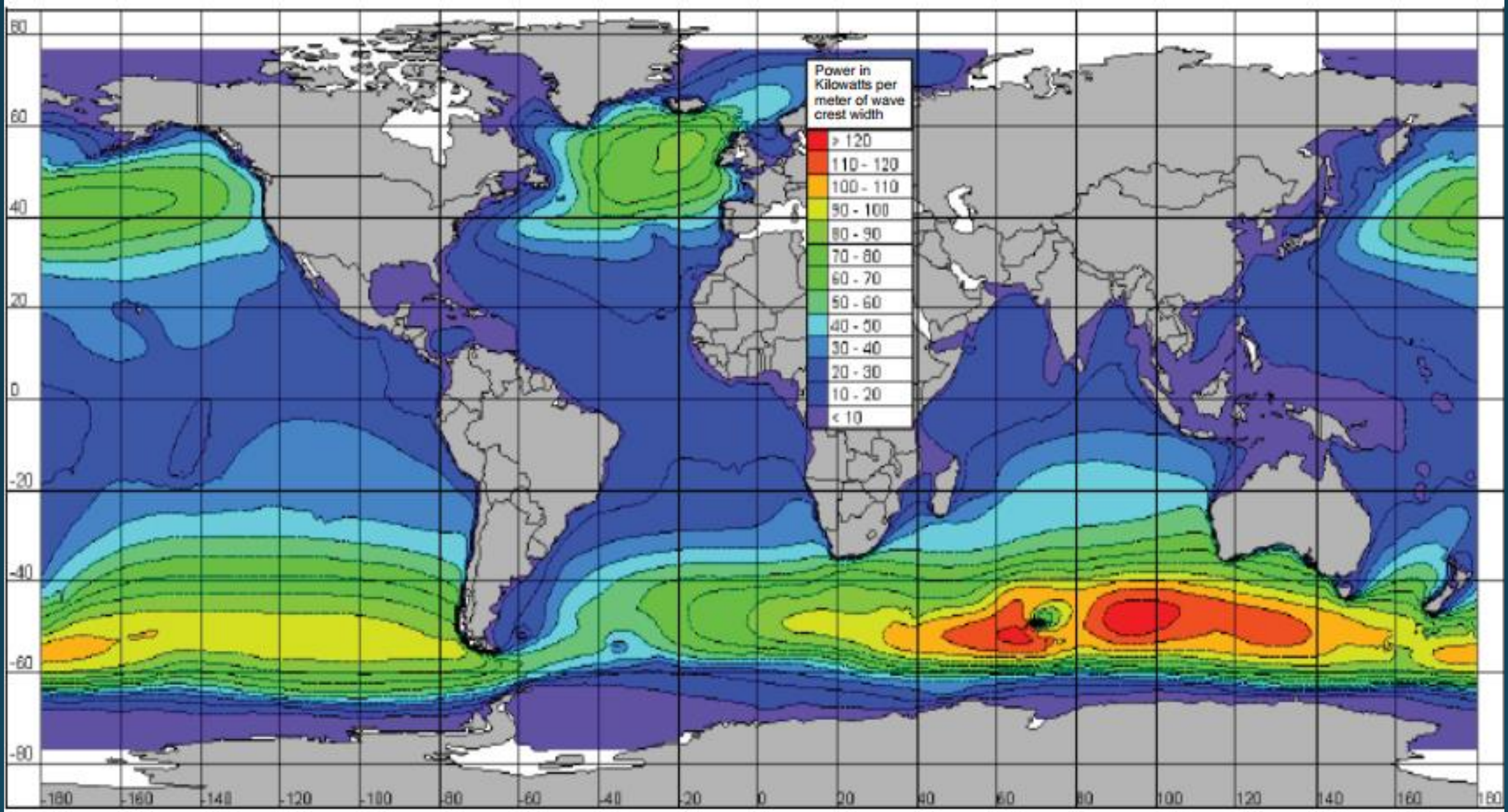
Underwater buoys will dampen the force from the anchors and make it horizontally directed.



Local conditions will determine how many units it is possible to have between the anchors.

The horizontal cables will be running below the surface. Service vessels will be able to operate above.

A radical idea for harvesting energy from ocean waves

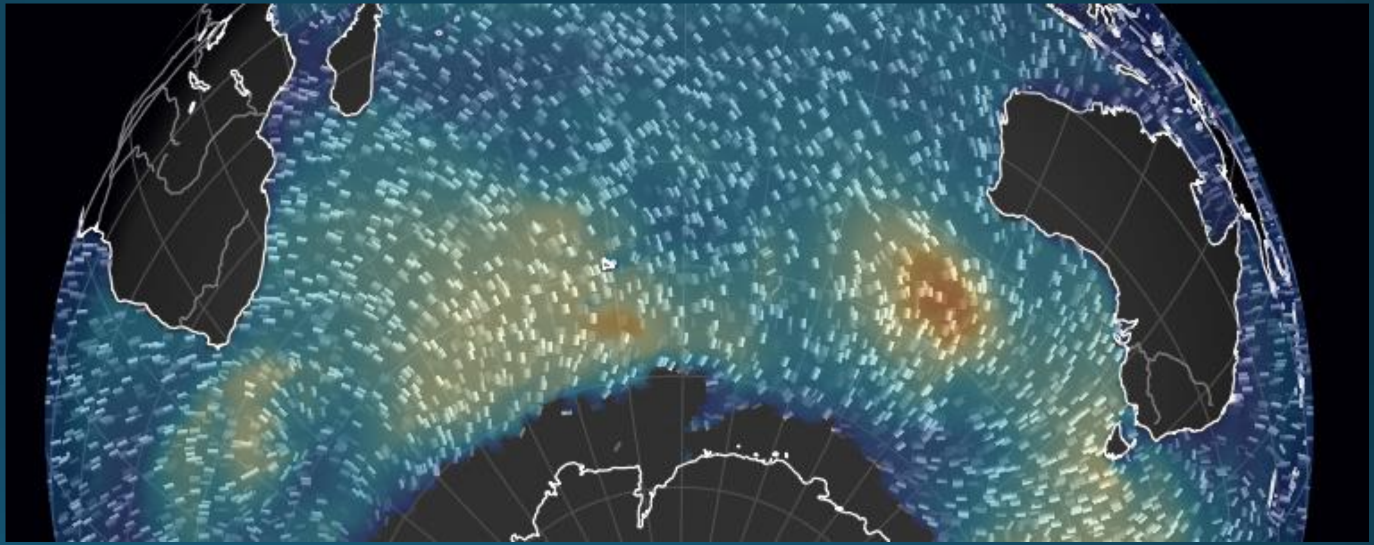


Cornett, 2008

This wave energy map shows that the greatest energy resources are concentrated in the west wind belts on the northern and southern hemisphere.

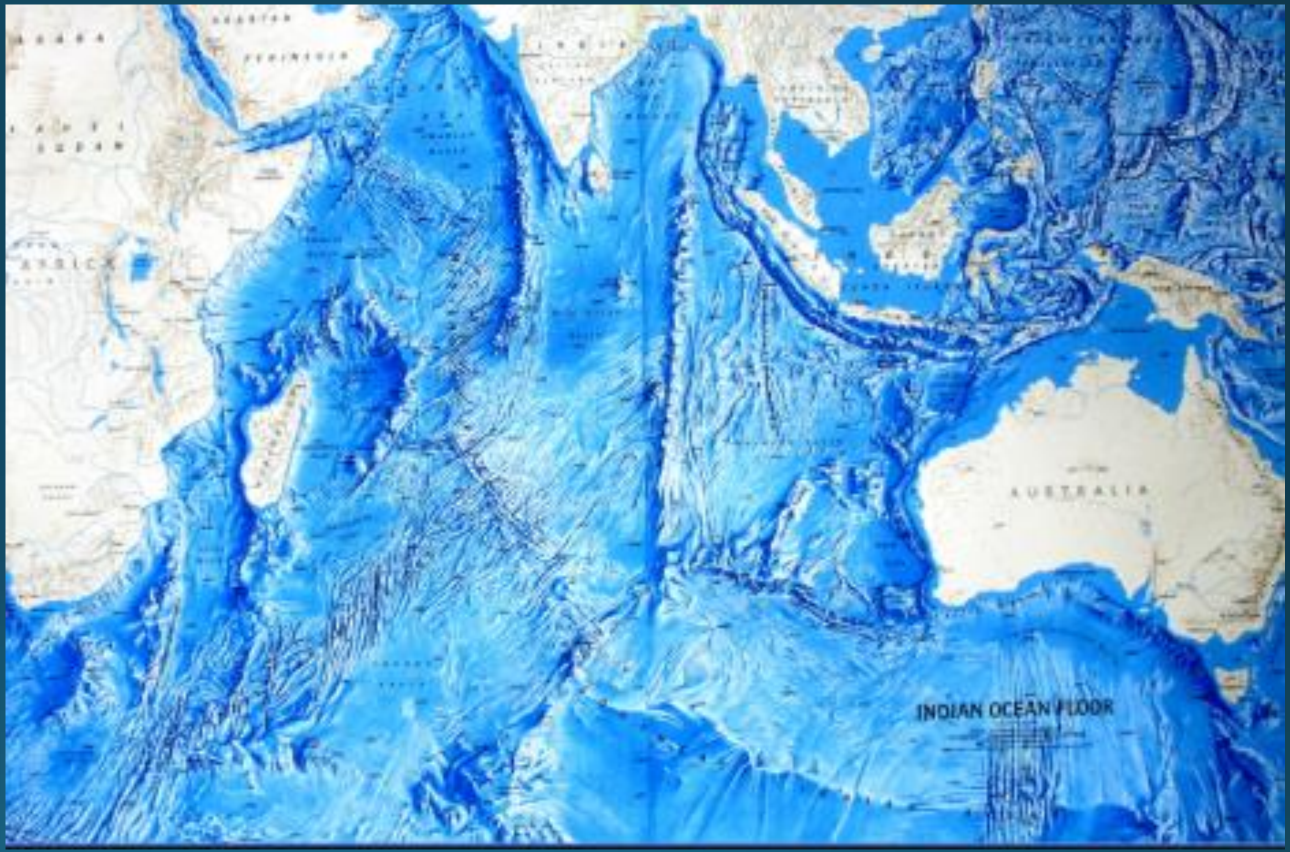
The vast west wind belt to the south constitute an enormous renewable energy resource.

The question is: How can we harvest this energy sustainably?

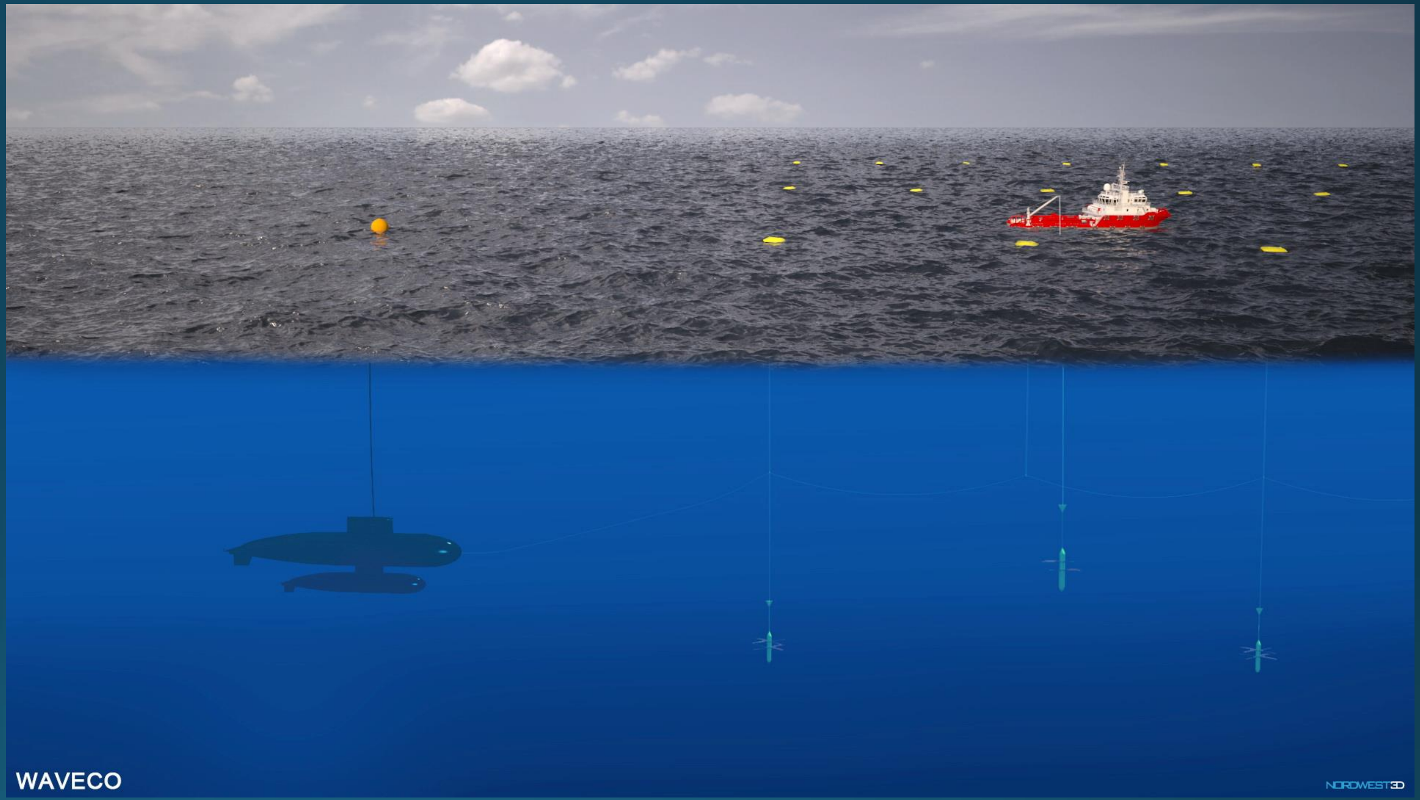


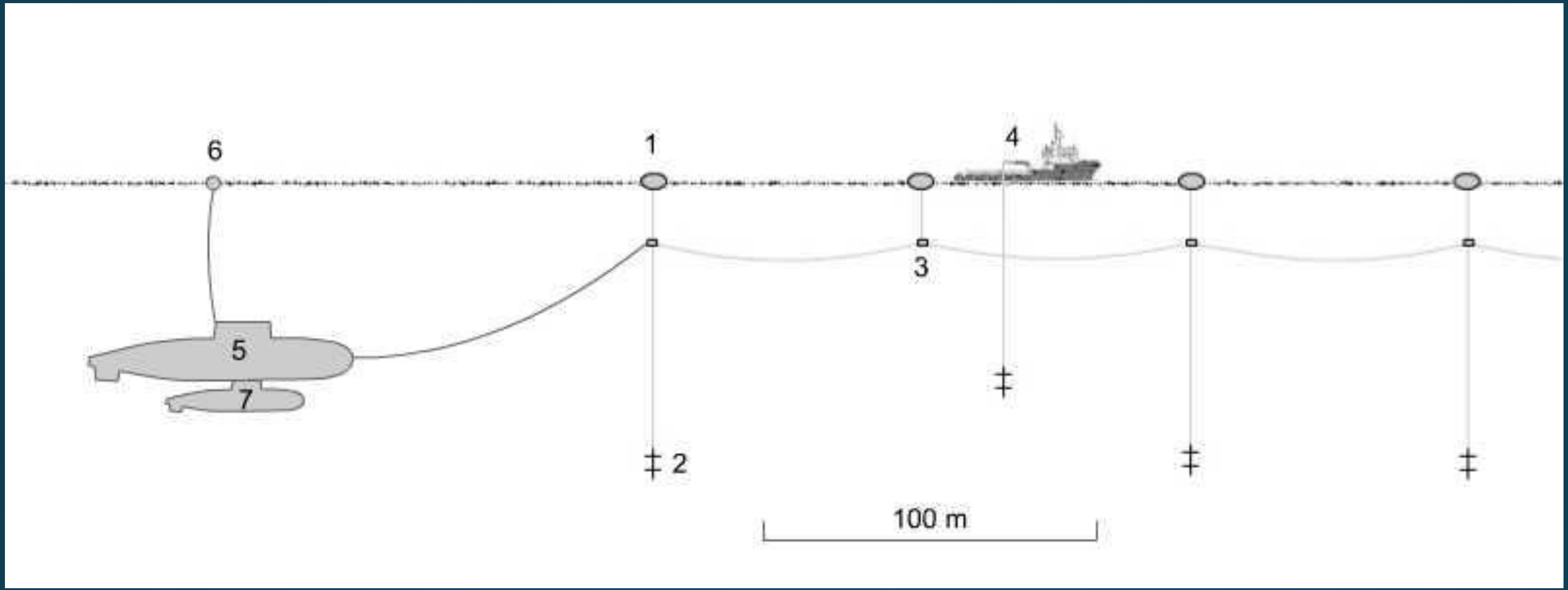
Mooring is not an option because of great ocean depths.

Due to depths and distances, energy export through landlines is also out of the question.



Our suggestion is hydrogen production in dynamically positioned sub surface installations.





Unmanned, submerged hydrogen producing factories (5) transferring compressed hydrogen gas to autonomous shuttles (7)
for transport to a land base. And hundreds of wave power units providing energy. Today this would be technically feasible. It would, however, be expensive energy, initially at least. But streamlining of the technology could make away with that hurdle since it would be completely autonomous.

The oceans cover 72% of the worlds surface. And land areas are increasingly in short demand. Coastal areas, too.

Maybe this kind of energy will be worth the price after all?

Because we are really running out of time.
Experts agree that global heating of 4C by 2100 is a real possibility. It justifies radical concepts.

The Observer Climate change

The heat is on over the climate crisis. Only radical measures will work

Experts agree that global heating of 4C by 2100 is a real possibility. The effects of such a rise will be extreme and require a drastic shift in the way we live

The Guardian
18 May, 2019

The tragedy is that we are transforming our world for thousands of years into the future just because we aren’t willing to pay for our prosperity with the real cost of energy.

Remember:

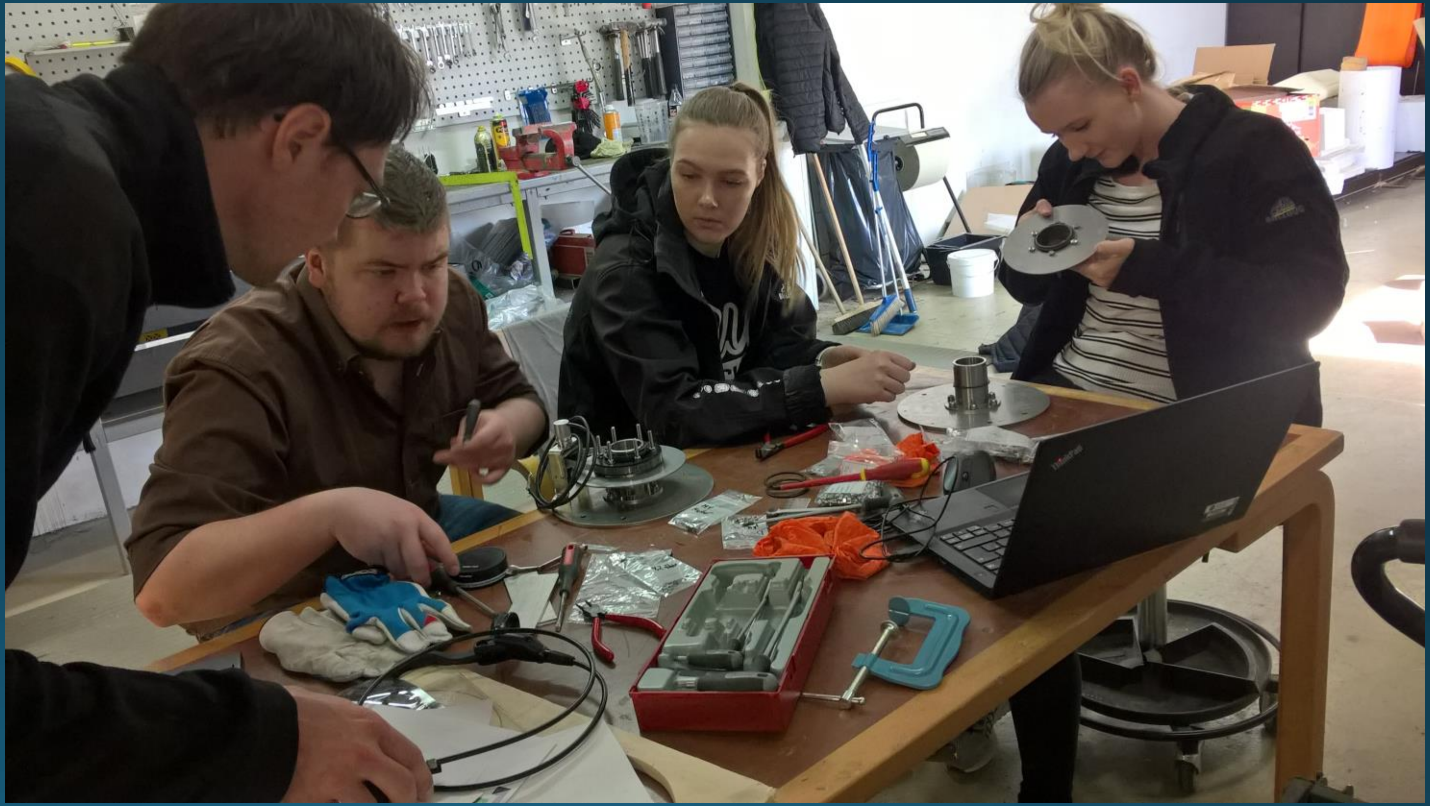
e last mile is the hardest.

Waveco has received pre-project funding from the Norwegian industrial cluster GCE Ocean Technology and our local bank.

For that we are grateful.

Our good neighbour, Stadt Towing Tank, is also helping us a lot.

Four groups of students from Western Norway University of Applied Sciences have solved problems for Waveco for their bachelor assignments.



These relatively modest resources have finally brought us to where we are now. We are about to finish a functional prototype, even if it is small, ready to be tested in the sea.

Financing

Our research is highly relevant to the UN Sustainable Development Goals.

7 AFFORDABLE AND CLEAN ENERGY

Based on the global climate crisis, state support schemes should have brought new renewable ideas into the fast track immediately, until their potential was clarified.

Instead, we are stuck in the queue, fighting for the interest of private investors looking for short term business.

Because private money is a prerequisite for getting support from Norwegian government programs.

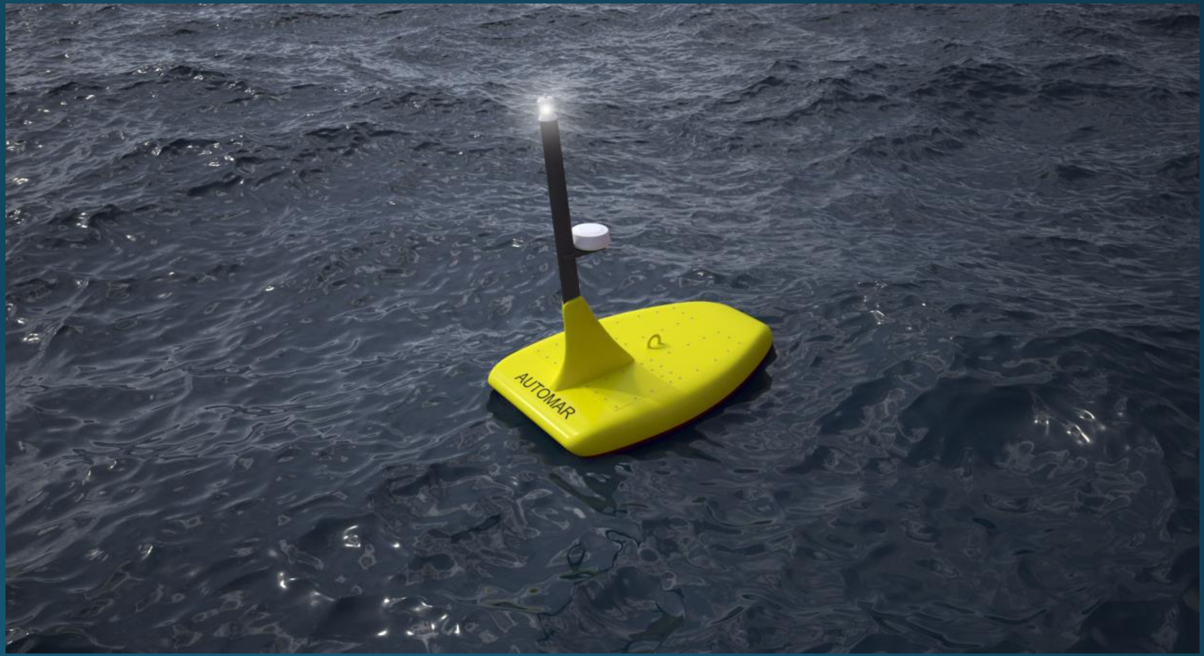
ENOVA

Innovasjon Norge

skattefunn

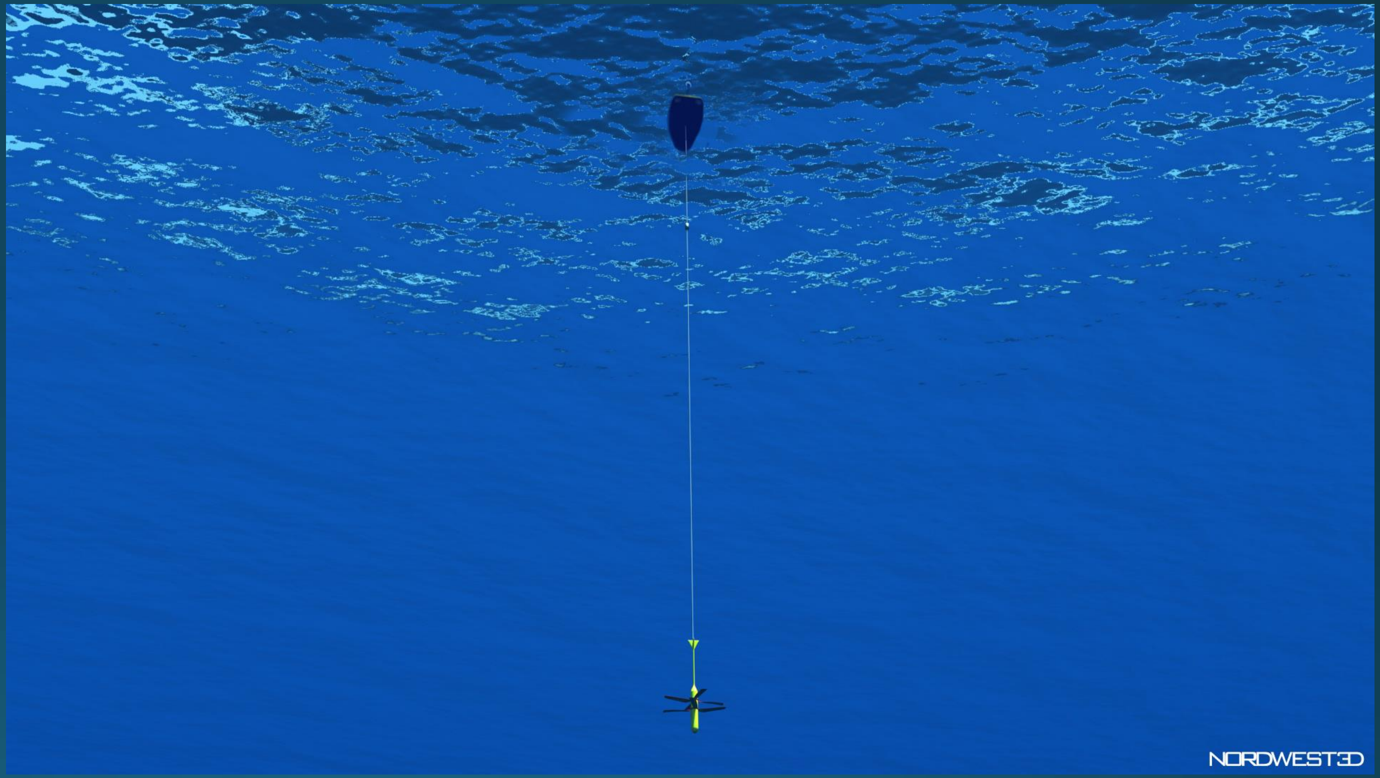
Forskningsrådet

We have therefore created a business idea that will hopefully be more attractive to investors:
The anchorless observation buoy, the **AUTOMAR**.

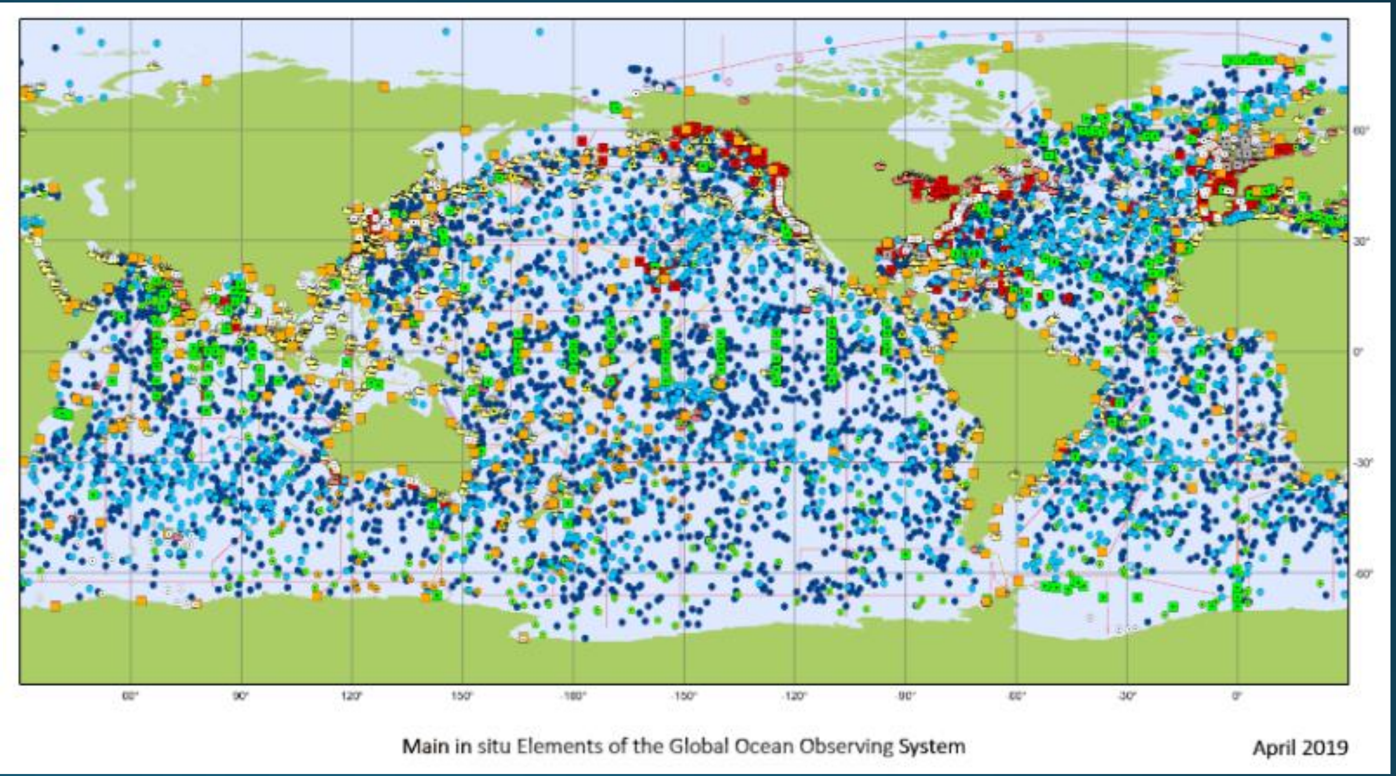


It will be able to hold its position for years, by means of GPS and thrusters. Engines and payload are powered by a large battery …

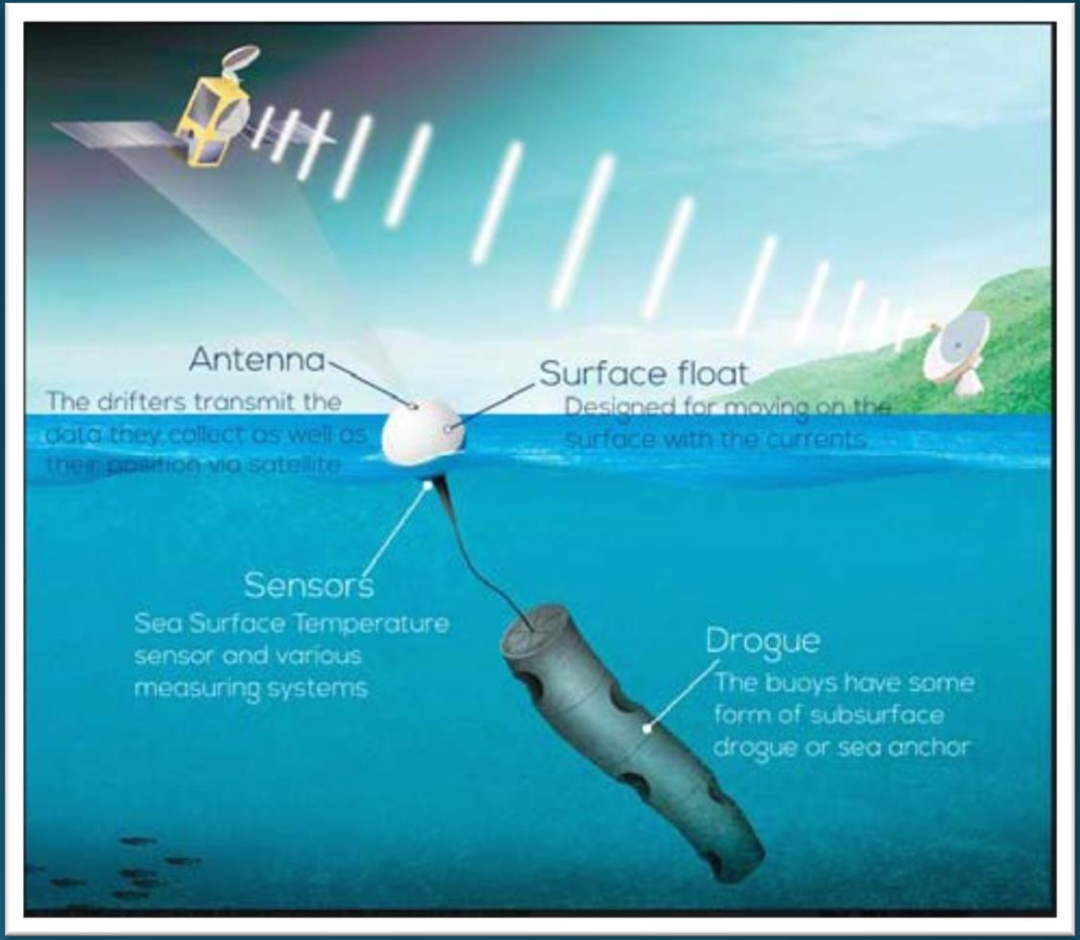
... constantly charged by the Subwave turbine working in the depths below.



We will introduce this for the large market of global ocean observing systems.



The AUTOMAR will enable long term observations, with a large array of instruments, from fixed positions in the deep oceans. These areas are now covered by small drifting buoys with simple instruments powered by small batteries.



To maintain coverage, one thousand new buoys must be deployed each year, from ships and planes.

AUTOMAR will make it possible to cover the oceans with buoys that stay in place.

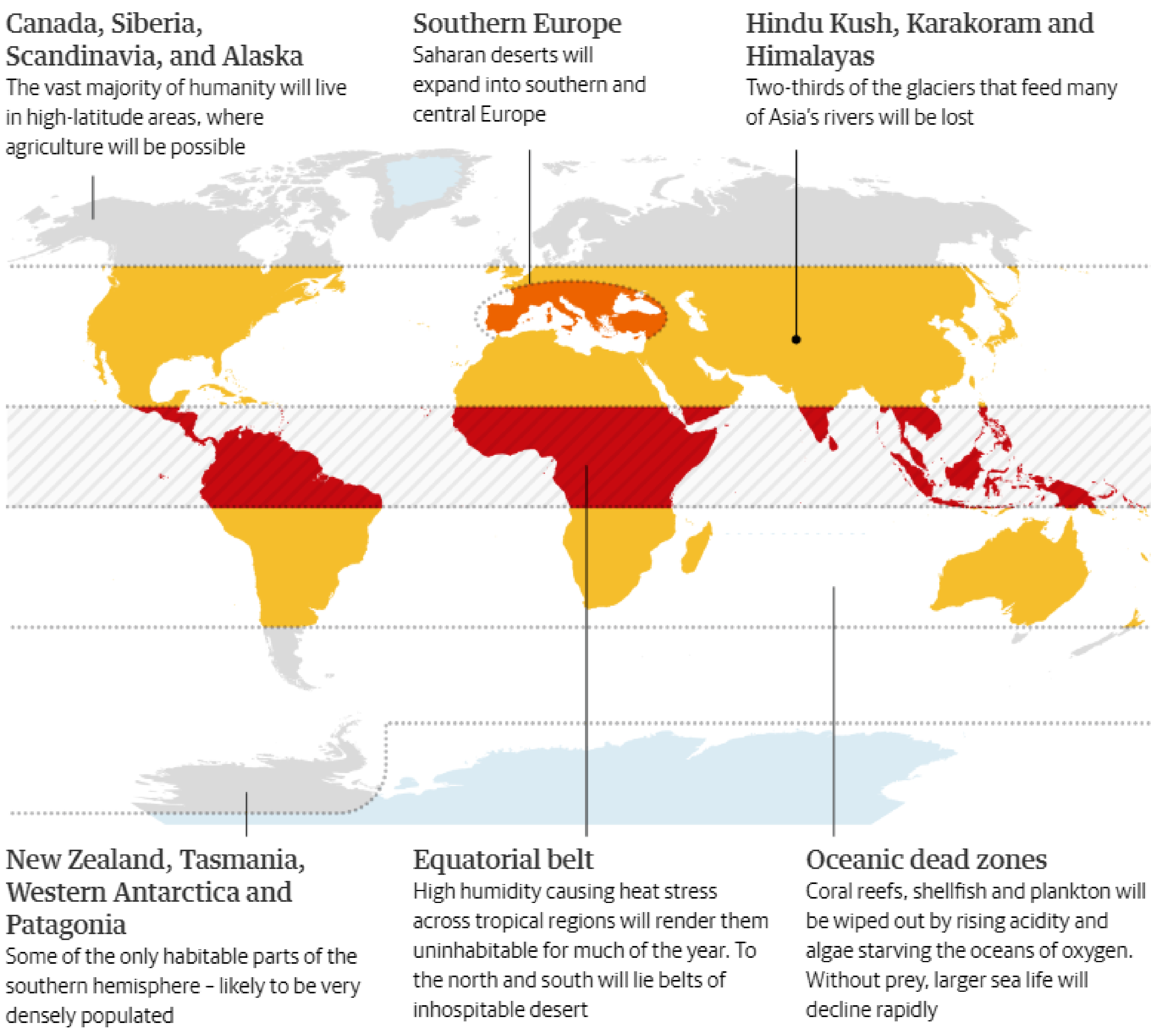
At the same time, AUTOMAR could become a precursor to dynamically positioned energy-producing units.

A world 4 degrees warmer than pre-industrial temperature would make large parts of the world uninhabitable.

A nightmare left to our children.

The Guardian
18 May, 2019

We can't allow that to happen!



Guardian graphic

Thank you for your time and attention!

Inge Bakke
Founder, CEO

Waveco AS
N-6740 SELJE, Norway

Email:
post@waveco.no

Mobile:
+47 9951 9795

Web:
waveco.no