

40 SOUTH ENERGY

WAVE ENERGY, RELOADED

SERIES 25 - WAVE ENERGY CONVERTERS

Michele Grassi is a mathematician who graduated from Scuola Normale Superiore in Pisa, Italy, and gained a PhD in mathematics from the University of California, Los Angeles. In 2005 he had an idea for a radically different method to extract energy from sea waves. After the initial preliminary studies, in 2006 he submitted a first PCT patent application which covers the extraction method. Afterwards, he submitted other patent applications, covering other innovative features of the machines.

2007: 40South Energy Srl formed in Pisa
2007: first prototypes in reduced scale tested offshore
2008: 40South Energy Limited formed in London
2009: offshore testing of mechanical 1:2 scale model
2010: offshore testing of first full scale 100KW machine
2011: offshore operation for 33 days of Series 25 prototype

The tests of Y25t (see main photograph) among other things validated the computerized models that we use to estimate the capacity factor in a given site, once we know the wave statistics for it.

The first Series 25 machine, a 25kW R1-25 model, will be delivered in the spring of 2012 to a small Italian power producer for installation in the Tyrrhenian sea. We are also in advanced negotiations for sales in the Maldives and in a grid connected site in Liguria, Italy. We have many other commercial leads all over the world. Currently 40South Energy employs engineers, technicians and scuba divers, and has the capacity to build, install, operate and maintain its wave energy converters. Michele Grassi has been the Chairman and CEO of 40South Energy since the start, and has overseen its evolution from pure R&D to be the first company commercializing a whole family of modular wave energy converters, the Series 25.

Series 500 and Series 2000 machines will become available in 2013 and 2014 respectively.



The Series 25 machines are formed by three sub-systems (see diagram opposite):

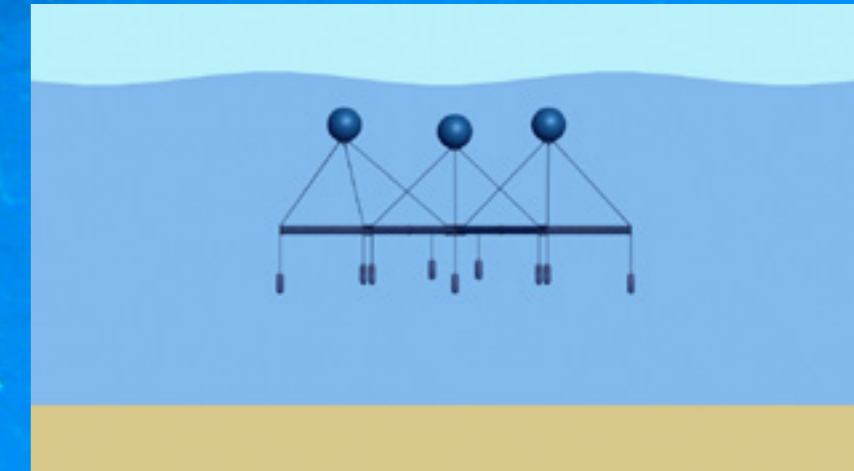
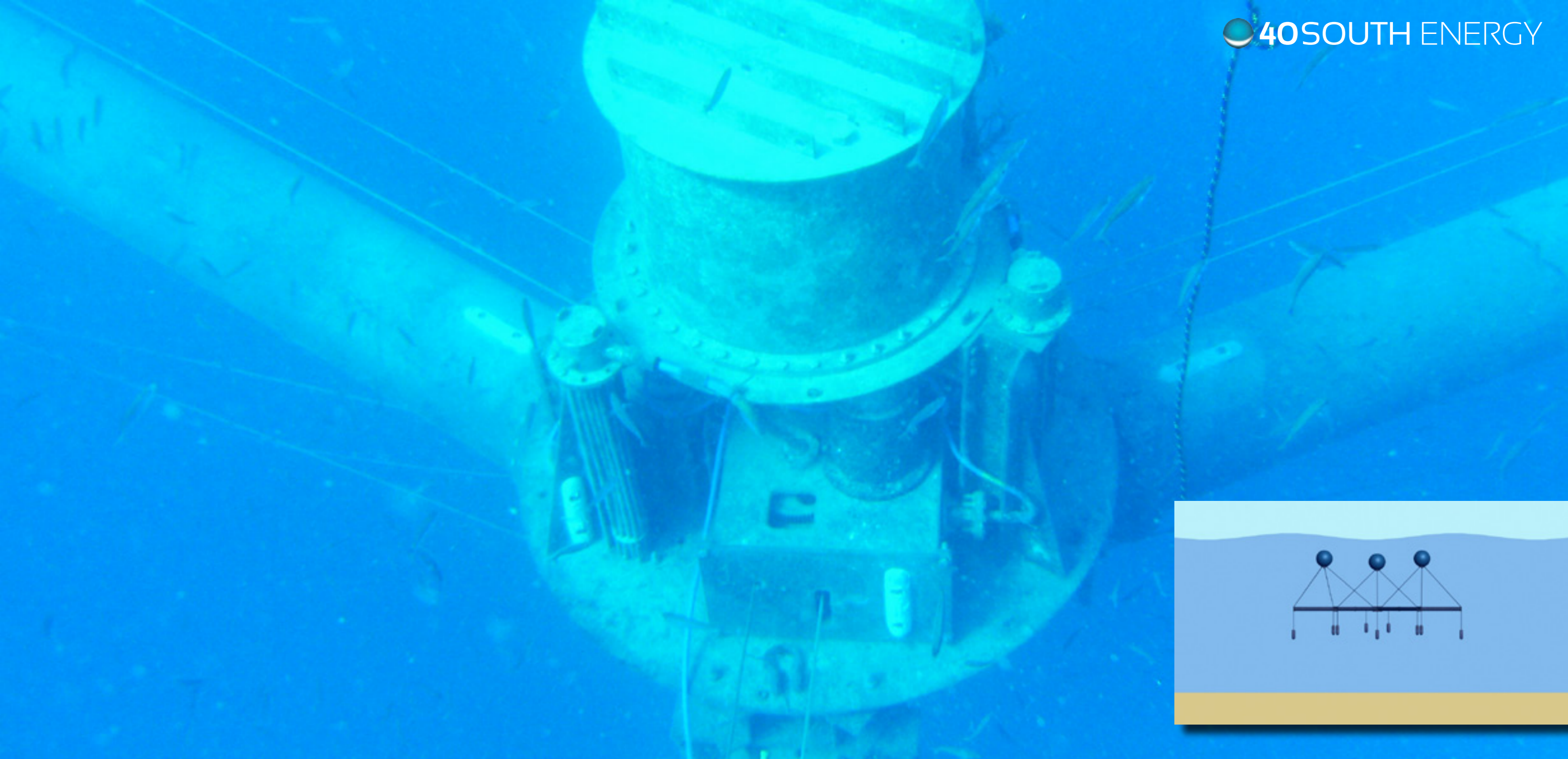
- The Upper Members, kept near the water surface
- The Lower Member, kept deeper and below the Upper Members
- The mooring system (not shown)

The Upper Members are exposed to higher wave energy levels than the Lower Member and, as a consequence, they tend to move more. From the ensuing relative motion we can extract energy, using our innovative (and patented) transmission system.

The wave machines from 40South Energy are based on several innovative solutions, which allow them, among other things, to move up and down autonomously in the water column, to seek their nominal energy level. This has some immediate benefits, such as:

- machine never exposed to excessive loads
- extremely high capacity factor
- low capital cost and reduced maintenance

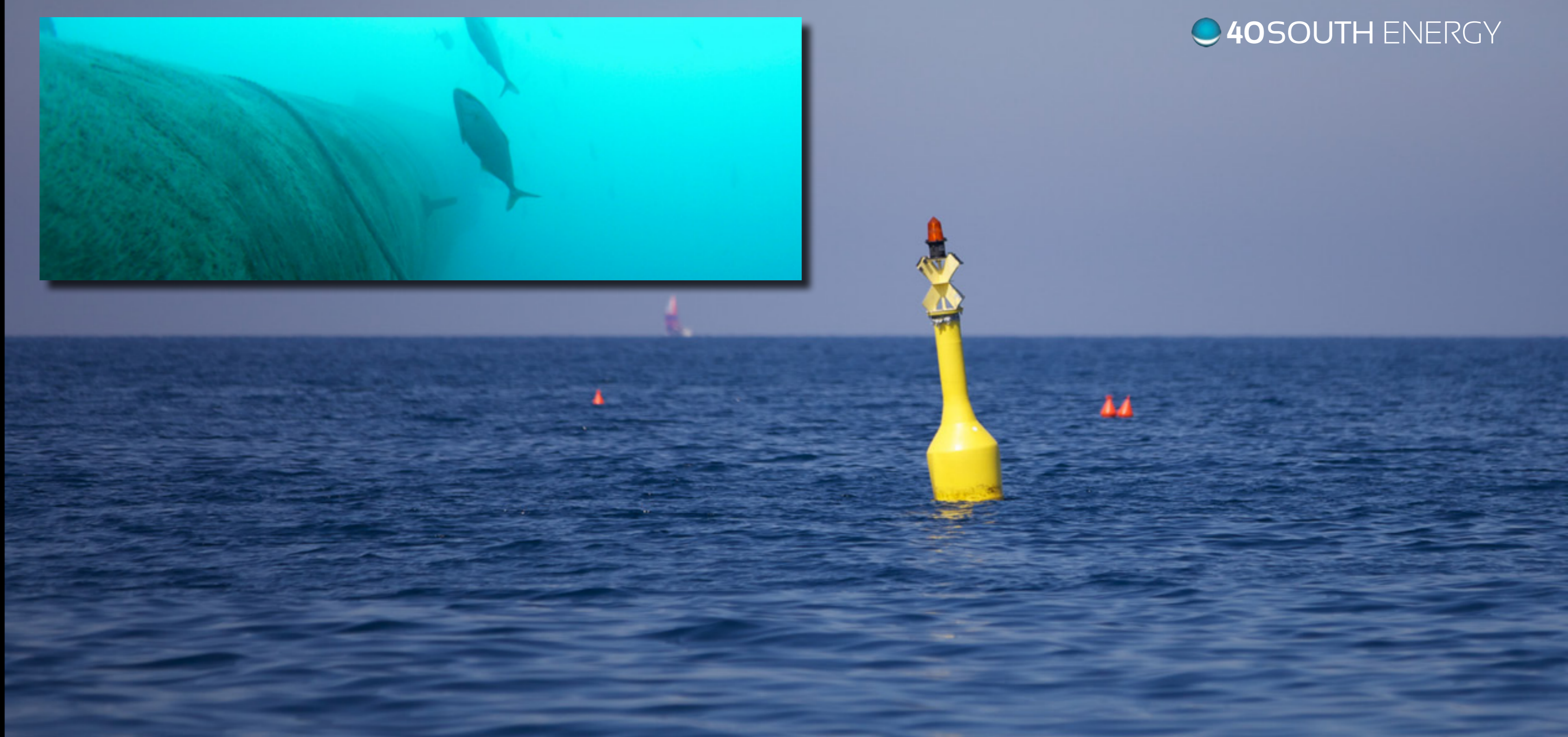
These features make them a contender with offshore wind right from the start, with the added advantage of much lower logistical requirements for installation. They pose no threat to navigation, because if a ship off course travels over their location (signaled by buoys and interdicted to navigation) they automatically sink to avoid collision. Guaranteed survivability, competitive cost of energy and zero environmental impact are our main differentiators from the other marine energy technologies.



The machines are always completely underwater, not visible. Because they can vary their depth dynamically to avoid collisions with off-course ships, they pose no threat to navigation. We verify at sea that they attract marine life, as any artificial reef. Large scale installations can produce a significant positive impact on local communities. As you can see from the diagram on the last page, most of the expenditure of a Wave Energy Park will go straight into the local economy, either from the Wave Energy Park personnel and infrastructure or from a local presence of 40South Energy Group (local warehousing, specialized personnel).

In addition to the direct positive impact, Wave Energy Parks have many other benefits, including:

- Series 25 machines can be used effectively in conjunction with offshore Fish Farming. For example, the power from the wave generating modules can be used for local refrigeration, to run the automatic food dispenser, and to power all the monitoring equipment and the lights used to accelerate growth of the fish.
- Excess energy can be used to produce oxygen for fish farming nurseries, and hydrogen for energy storage, through electrolysis.
- Excess energy can be used for freshwater production via desalination.
- The possibility of using the excess energy for refrigeration: modern refrigerators can work with intermittent power sources, as they have good thermal insulation from the surrounding environment.
- The protection of the marine environment, due to the added monitoring.



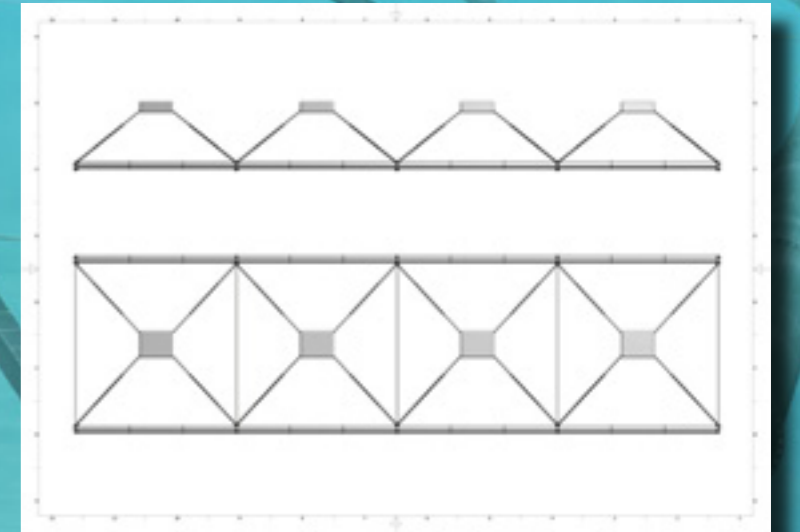
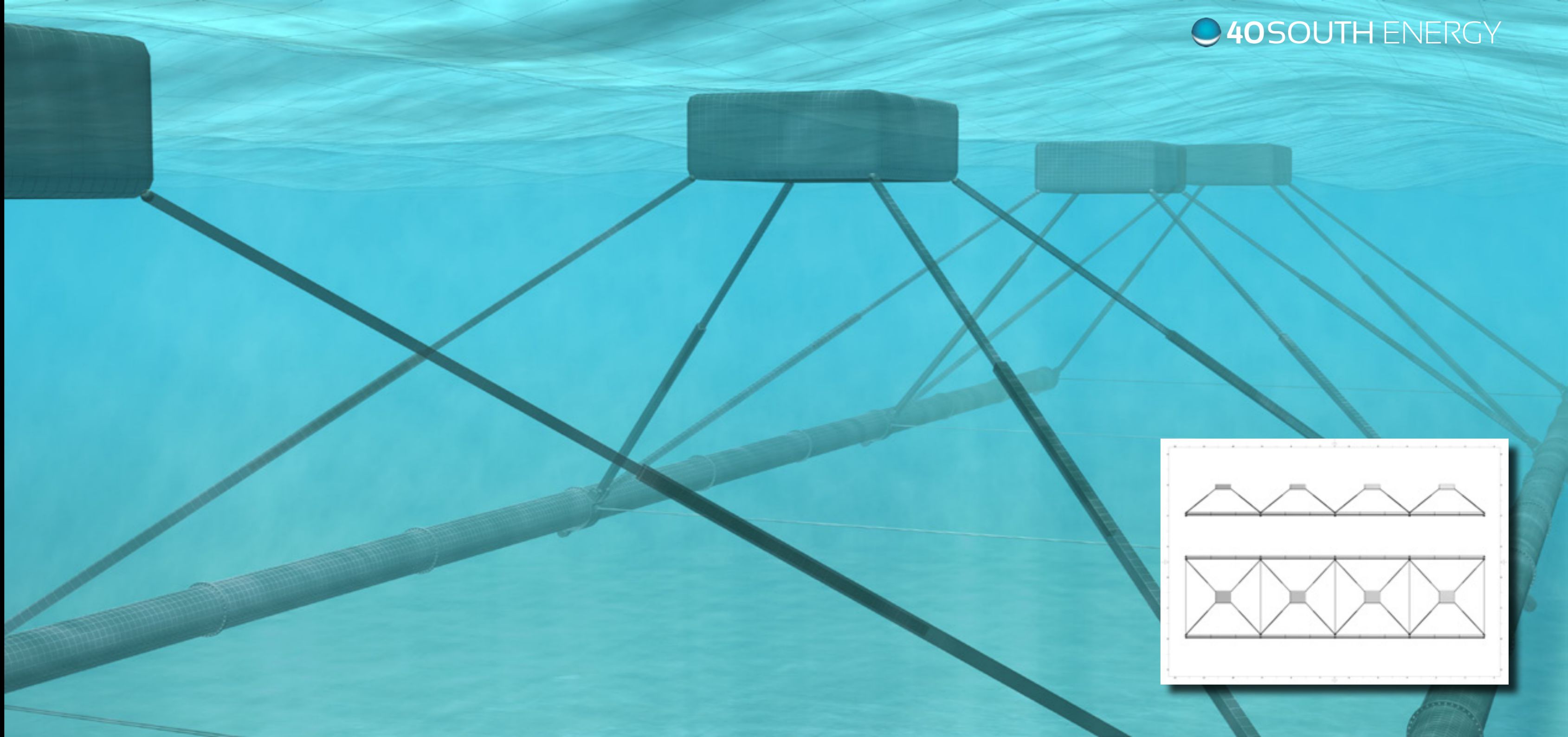
SERIES 25: TECHNICAL DATA

Installation, operations and maintenance: The machines are assembled in the harbor, and towed to the Wave Energy Park site with a standard towboat, where the electrical cable and connector and the mooring had been prepared in advance. The machine is then connected to the mooring and to the electrical cable, and then is instructed remotely by 40South Energy to find autonomously its position. During all these procedures there is no need for scuba divers or ROVs. The first level (on site) ordinary maintenance is carried out by the Wave Energy Park personnel, who can be sourced locally and trained by 40South Energy. The operations consist of removing the TEP modules from the machine and replacing them with the spares shipped in in advance by 40South Energy.

Power rating: The machines of Series 25 produce 25kW of nominal power for each Upper Member, and can have from 1 to 12 of them. Nominal powers range from 25kW (the R1-25 machine) to 300kW (the R12-300 machine). They are DC current machines, with a footprint of the power produced user-side that is very similar to that of a solar PV plant over a short time-scale. On longer time-scales the output is much more stable than that of wind turbines.

TEP modules: All moving parts, the electronics and control systems are housed in removable modules called "TEP" (for "Transmission Electronics and Power"). The TEP modules contain the electrical generators, the transmission system and the power electronics and control electronics. The system is purely electrical-mechanical, and this guarantees high conversion efficiencies and long maintenance cycles.

Capacity factor: These machines have capacity factors expected to be between 30% and 40% in Mediterranean conditions, with a wider range (both high and low) possible at specific sites. In oceanic conditions the Series 25 machines can achieve capacity factors above 70%, which is a level beyond that of most of the other renewable technologies. In the drawings there is a view from the top and a perspective view of an R4-100 machine with 4 Upper Members and 100kW of nominal power.



BUSINESS MODEL

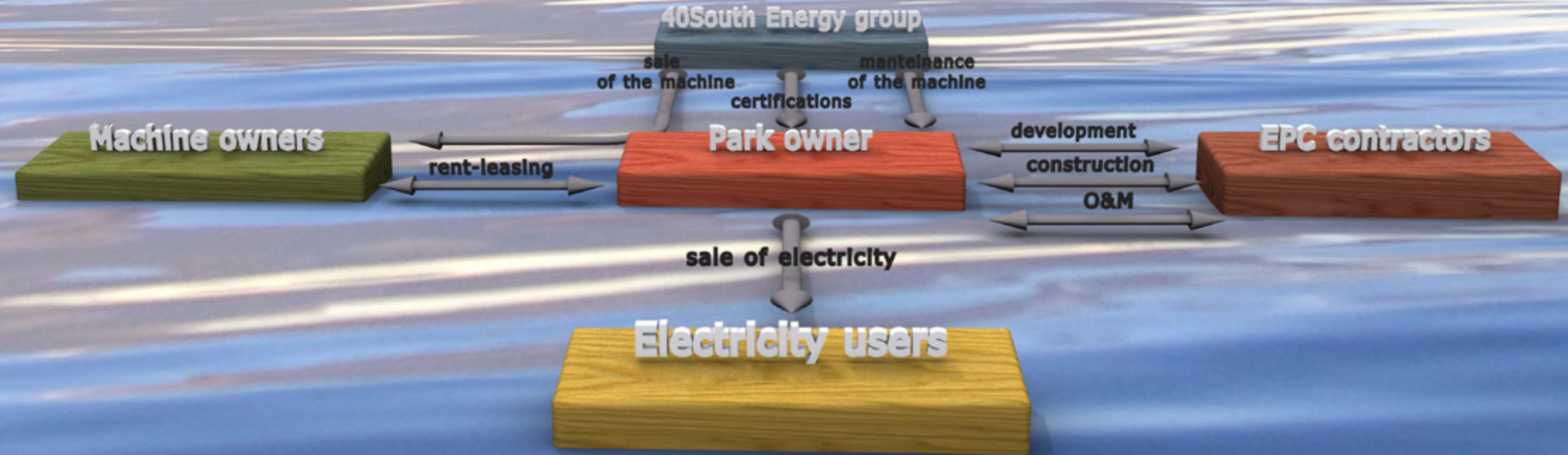
The illustration on the right explains the essential parts of a deal for the sale and installation of wave machines in a Wave Energy Park. The structure departs slightly from the usual one for, say, offshore wind, because here the focal point is the Wave Energy Park owner.

The Wave Energy Park owner acts as a distributor for the machines, and as an interface between the machine owners and the energy users. It is also the coordinator of the consenting process and of the construction and operation of the Wave Energy Park. The Wave Energy Park signs Power Purchase Agreements (PPA) with the electricity users, to guarantee its income.

The machine buyers 'rent' the machines bought from 40South Energy Group to the Wave Energy Park, which acts as a distributor and then uses them to produce energy. In some respects the machine owners act as (and could well be) a leasing company. The machine buyer can be a leasing company, or an ad-hoc company built to enable project finance.

The Wave Energy Park owner can also be the machine owner (as in the case of a Utility), so that the scheme 'collapses' to the standard one in which a Utility buys the machines and commissions to an EPC contractor the setup and operation of the Wave Energy Park. In this case, however, typically the IRR of the Wave Energy Park can be set to zero (or near zero), so that the power purchase agreement must only cover the LCOE of the Wave Energy Park. In these situations 40South Energy Group can take over the Wave Energy Park operations, at least in part, if requested.

In another situation (as in the case of very small installations) the machine owner can coincide with the electricity user. Also in this case the Wave Energy Park is necessary, to carry out consenting, construction, O&M and to insure that the quality standards necessary to retain certification are preserved.



The machine buyer can be a Leasing company, or one or more investors. The return in investment associated with the operation (IRR) is fixed at the signature of the contracts. The wave machines are rented to a Wave Energy Park for energy production.

The machine buyers do not have to deal with any technical due diligence, and although the single operations can be of small size, the product 'wave machine' is completely standardized even across different jurisdictions; this makes the leverage of Project Finance more easily accessible.

A machine buyer can even set up an operation in which the machines are placed in different Wave Energy Parks across different jurisdictions deliberately, to hedge its risks. This allows for operations very large size, even if every single Wave Energy Park may absorb only part of them.

The Wave Energy Park can request that 40South Energy provide a 'capacity factor certificate'. If this is in place, it is possible to price the machines on average power instead of nominal power. This guarantees to the machine owners a predetermined IRR independent of the actual production of the machine while, in addition, shielding the Wave Energy Park from the risks associated with having a fixed cost and an income linked to production. For comparison, one has

	Cap factor	€/nominal watt	€/average watt
Offshore wind-UK	0.35	3.8	10.8
Onshore wind-UK	0.25	1-1.3	4-5
Solar PV-UK	0.11	2-2.5	18-23
Solar PV-India	0.18	2	11
Solar PV-Italy	0.14	2.8	20

In Wave Energy Parks with a certified capacity factor, we propose to the machine buyers a competitive price per average watt based on the expected capacity factor and size of the order.



In locations not connected to a grid, both on islands and on remote continental locations, or in grid-connected installations in energetic sites, our machines can be competitive economically even without any green incentives. Here is a hypothetical cost breakdown for a 1MW installation near shore:

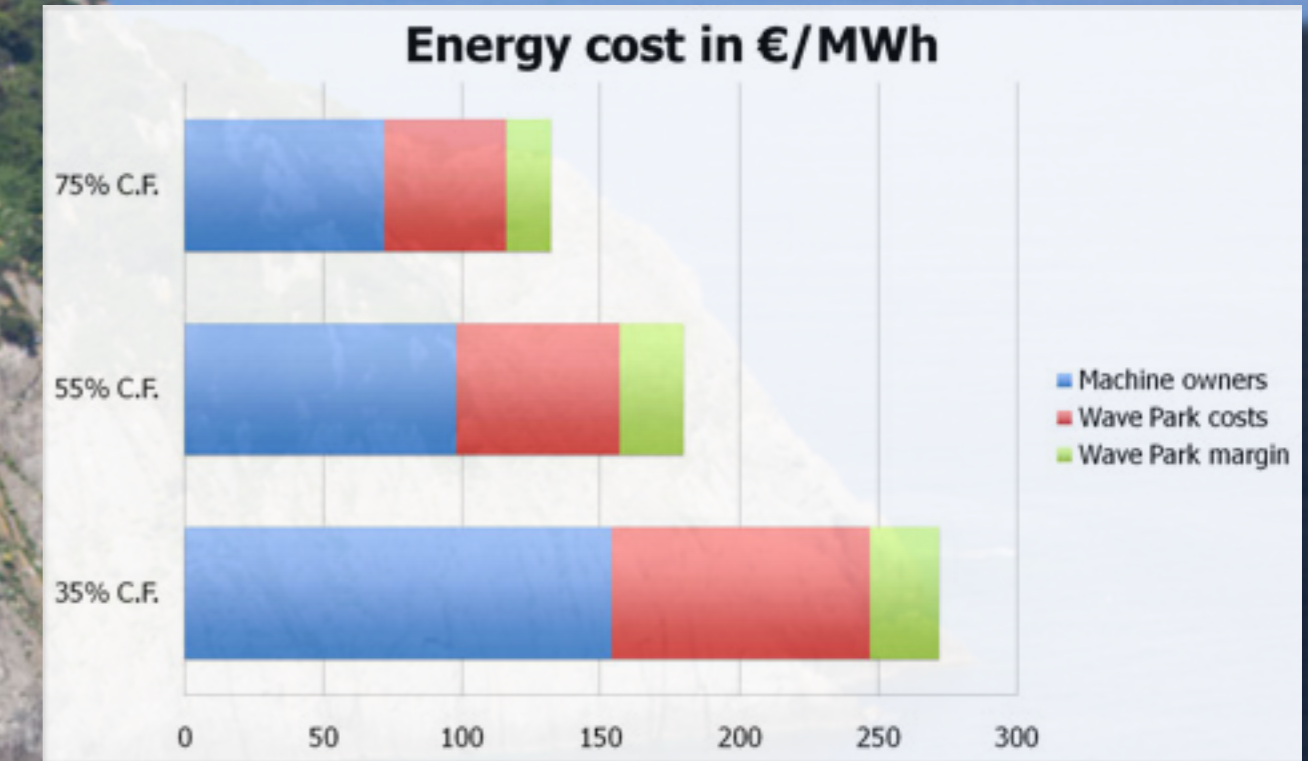
10 R4-100 machines.....	5M€
Laying 0.5NM of cable, 1MW 3kV DC.....	0.5M€
Load balancing inverter.....	0.2M€
Second level operations and maintenance	150,000 €/year

We compute three scenarios for a 25 years installation, assuming no debt in the financing of the Wave Energy Park operation, and a financing at 6% over 10 years of 60% of the machines bought, with capacity factors at 35% (Mediterranean sea), 55% (low latitude ocean) and 75% (high latitude ocean). If the Wave Energy Park owner is also the Machines owner, and is interested in obtaining the electricity at the cheapest price, the Power Purchase Agreement (PPA) must cover only the Levelized Cost Of Energy (LCOE) of the Wave Energy Park. We call this a 'service only' Wave Energy Park.

35% certified capacity factor: The Wave Energy Park operator pays a machines rent (or leasing fee) of 154€/MWh (blue area on diagram opposite), to give the owners an IRR of 10%. It faces an investment of 700,000€ and an annual cost of 150,000€ for second level maintenance and further 100,000€ for first level maintenance (35.7% of its CAPEX) for a 1MW plant. The LCOE for such an operation (blue + red areas on diagram) is in the order of 247€/MWh, and to get an IRR of 15% the PPA must guarantee 282€/MWh

55% certified capacity factor: The Wave Energy Park pays a machines rent (or leasing fee) of 98€/MWh, to give the owners an IRR of 10%. The LCOE for such an operation is in the order of 157€/MWh, and to get an IRR of 15% the PPA must guarantee 180€/MWh

75% certified capacity factor: The Wave Energy Park operator pays a machines rent (or leasing fee) of 72€/MWh, to give the owners an IRR of 10%. The LCOE for such an operation is in the order of 116€/MWh, and to get an IRR of 15% the PPA must guarantee 132€/MWh



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