CHOICE OF ENERGY CONVERSION EQUIPMENT

1. Equipment Review

The World's first wave power plant was Akuacadura (Portugal). It used three Pelamis wave energy converters with a total installed power of 2.25 MW. The power plant started producing electricity in July 2008 [26]. The Wave Power Islay LIMPET was installed and connected to the National Network in 2000. and is the World's first commercial wave-powered installation. Scotland funded a 3 MW wave power plant in Scotland on 20-th February 2007. [27].

"Bombora wave power" [28] is located in Perth (Western Australia) and is currently developing a “mWave” [29] flexible membrane converter. The CETO wave power plant at the western coast of Australia operates to demonstrate commercial viability and has been further developed following an environmental impact assessment [30, 31]. Two fully submerged buoys attached to the seabed transform ocean energy into hydraulic pressure on land. It drives the electric generator as well as produces fresh water [32, 33]. Ocean Power Technologies (OPT Australasia Pty Ltd.) is a 19 MW wave power plant connected to the network near Victoria (Portland) [34]. By the end of 2013., Oceanlinx planned to establish a commercial scale demonstration device for Port MacDonnell (off the coast of South Australia). This device, called GreenWAVE, has an electrical capacity of 1MW [35]. Reedsport, Oregon – Commercial Wave Power on the US West Coast, near Reedsport (Oregon). The first phase of this project was designed for ten PB150 PowerBuoys or 1.5 MW [36, 37]. Kaneohe Bay Oahu, Hawaii – Fleet Energy Research Area (WETS), which is currently testing the Azura wave power unit [50]. The Azura Wave Power Unit is a 45-ton wave power converter located 30 meters deep in Kaneohe Bay [38]. Eugen Rusu provides information on wave states and the efficiency of wave transformation in three different types of coastal environment: Continental Ocean, island environment and marine environment. The review evaluates several types of converters that cover a wide range of existing offshore installations [39]. The author believes that the future belongs to converters with variable capacity. Authors V. Jayashankar, K. Mala, S. Kedarnath, J. Jayaraj, U. Omezhilan, and V. Krishna [40] highly appreciate the prospects of oscillating columns for commercial production electricity. Equipment with an average energy of 24 kW / m and the ability to produce 100 GWh in two years is described. Simulations show that turbine efficiency can exceed 60% (10-100%) of rated power. It has been shown that a wavelength of about 660 m with 11 turbine generators is sufficient to meet design requirements and an average wave efficiency of about 36%. Of course, 60% has a high efficiency factor, but the machine is massive and therefore thought to be expensive (Fig. 1).

Fig. 1. Indian wave power converter (*OWC*) [40]

Obviously, efficiency is calculated not from the power of the wave, but from the average air flow capacity.

2. Equipment Classification

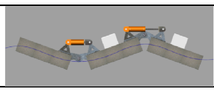
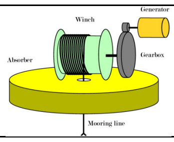
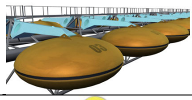
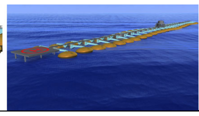
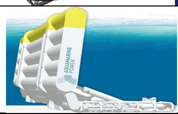
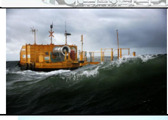
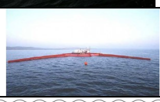
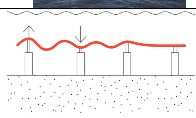
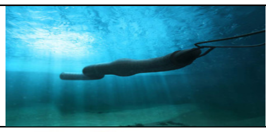
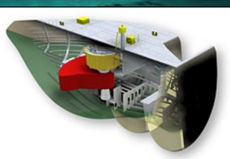
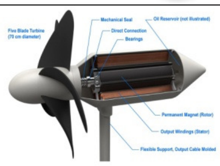
There are around 240 different projects in the world. The equipment differs according to the operating principles by which it can be classified. The ITTC article [41] provides a classification of wave transformers depending on whether the structure is fixed or floating.
In the IRENA article [42], the basic principle of the classification of equipment is also whether the structure is fixed or floating and then further expanded according to the location of the site.

However, it has to be admitted that all wave-conversion devices are designed to optimize wave energy conversion. That's why we offer to classify them according to the principle of operation and the area of deployment – shallow-water, medium-depth and deep-water zones. (Table 1).

We offer to evaluate wave transformation equipment by operating principle and placement area – shallow (*Sh*), medium (*M*) and deep (*D*) water areas. (Table 1).

Table 1.

Classification of wave conversion equipment

	Type	Illustration	*Sh*	*M*	*D*
1	Surface damper [43]			x	x
2	Float type absorber [44, 45, 46]	  	x	x	x
3	Fluctuating wave stream converter [47]		x		
4	Air pressure camera [48]		x	x	x
6	Overflow converter [53]		x	x	x
7	Underwater pressure difference receiver [49, 50]		x	x	
8	Air bubble engine [51]			x	x
9	Rotating mass [52]			x	x
10	Flow turbine with horizontal axis [53]		x	x	
11	Flow turbine with vertical axis [54]		x	x	x

3. Converter Model

3.1. Analysis of the Examined Equipment

According to the classification of the equipment, we can conclude that all the equipment can work in the middle depth zone. Criteria for the operation of prospective equipment can be set as additional criteria:
1. The ability to change the depth of immersion and / or the simplicity of this option;
2. Positioning the machine against *mwd* and / or the ease of positioning.

We will classify the equipment according to these two criteria (Table 2).

Based on 3. Table 6 (Underwater Pressure Differential Converters) and 10 (Flow Turbine with Vertical Axis) is worth considering. To select the more promising of these two types of equipment, we will set additional criteria:
1. The ability to lock the receiver to the required depth;
2. The ability to convert wave energy into rotational motion.

Let's compare the two types of equipment chosen on the basis of these criteria (Table 4).

2. Table

Evaluation of wave conversion devices by their possibility of fixing the receiver to a specific depth and possibilities to convert wave force to rotational movement

No	Type of the transformer	Option to fix	Option to get rotation
7	Underwater differential	Complicated	Complicated
11	Turbine with vertical axis	Easier to deal with	Simple

The selected machine is thus a turbine with a vertical axis.

3.2. Justification of Equipment Chosen

The justification for the chosen equipment is based on an analysis of its performance.

Despite the fact that the turbine diameter is also limited by the vector velocity of its rim, this type of turbine does not need a positioning mechanism with respect to *mwd*. This means that Fig. 6. in the illustrated block diagram, position 2 in the particular mechanism is already incorporated in the mechanism itself. These types of turbines can be combined with offshore wind parks, for which a patent application has been prepared in the context of the promotion work.

For any newly developed device, it is necessary to estimate the most important parameters that determine the advantage of this equipment before performing the *TRL 9* stage. Let's define the following parameters:

1. Expected capital costs (*CAPEX*);
2. Expected running costs (*OPEX*);
3. Efficiency curve of the device.

CAPEX has to be divided into two components, as part of this item can be credit interest, the rates of which depend only on the financial market, but not on the technical solution. Of course – the total amount of credit interest depends on the amount of the loan in the investment. Therefore, the second part of *CAPEX* – investment is important. Perhaps the most successful investment appraisal is the depreciation of the plant, as it depends on the initial investment and the depreciation period.

OPEX depends on the cost of maintenance (*TA*) and repair (*R*).

The machine utilization rate curve will depend on how efficiently it transforms the forces in the waves at the specific wave potential conditions.

Taking into account the parameters defined above, the model chosen by the equipment mentioned in the survey is a turbine with a vertical rotary axis and self-adjusting blades (*SAB*) (Fig. 2).

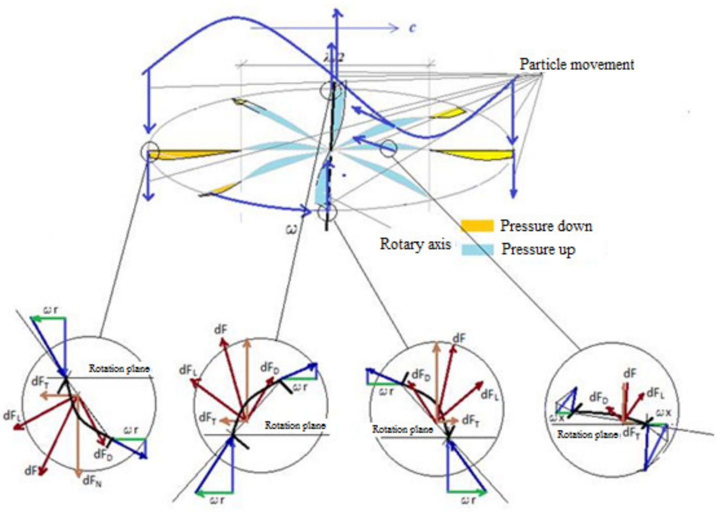


Fig. 2. Turbine with vertical rotary axis and *SAB*