Research of Natural Renewable Energy Resources of Coast and Seas of the Far East

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Abstract

In article renewed energy sources on Far East of Russia are considered: thermal energy, energy of salinity gradients, tide, waves, currents, a wind and solar power. Estimations of power resources of these energy sources are given. Places in which they are offered can are effectively used.

A system of autonomous power supply for a coastal facility for the cultivation of hydrobionts from renewable sources on the island of Popov is proposed. A device for growing hydrobionts on artificial automated plantations in the water column without diving with an autonomous power supply from renewable sources has been developed..

Keywords: source of energy, thermal, salinity, tide, wave, current, wind, solar, hydrobionts

1. Introduction

The Far East of Russia is the region of Russia where the primary start of development and use of ocean energy sources is possible, this is facilitated by the fact that the Far East has a long coastline and most of the territory of the Far East is not connected to the unified energy system. And as the population density in these territories is small, it is economically justified to use autonomous energy sources, and, first of all, renewable energy sources of the ocean. The territory of the Far East stretching from the south to the north of 4500 km, more than 70% of the length of its borders falls on the shorelines of the seas of the Arctic and Pacific Oceans, covers different natural areas, and almost everywhere the potential of renewable energy sources is very high. The Far East has the longest coastal line among the regions - 17,700 km. (with islands).

The population of the Earth grows; requirements for marine foodstuff accordingly increase. The aquatic organisms grown in pollution-free natural settings of seas of the Far East of Russia are especially appreciated. Aquaculture development in this region is complicated small population, remoteness, absence of the production engineering, allowing to develop continuous process in the conditions of a frigid climate and high ecological requirements. This paper is devoted researches in power supply from renewed sources and working out of a perspective complex of a marine aquaculture.

2. Source of energy

2.1. Thermal energy of the ocean

In ocean thermal energy conversion (OTEC) the difference in temperatures of warm surface water and cold deep water is used to generate energy. The resources of this type of energy in the oceans are huge. But basically they can be used in the tropical zone of the ocean. In the Russian Far East, only in the southern regions and only part of the year is it advisable to transform the thermal energy of the ocean by traditional methods. It is still possible to increase temperature differences using warm water from shallow natural and artificial, sun-warmed water bodies or warm drains of some enterprises.

Therefore in the laboratory of the energy of the ocean it was proposed to use the temperature difference between the outdoor air and sea water in the cold seasons of the year. For the northern regions of the Far

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East, these seasons are long and the potential of the thermal energy of the northern seas is extremely high. In addition, energy can be obtained from this source precisely when energy requirements are high. Transformers of thermal energy of the ocean with low-boiling heat-carriers were proposed.

2.2. Salinity gradient energy

Places where there are differences in salinity (concentration) of natural waters and solutions can be used as energy sources, which are called salinity gradient energy (SGE) sources. As sources of energy, salinity gradients are considered, first of all, the mouths of rivers flowing into the sea. The energy density of these sources is high. So, it can be imagined that in the mouths of rivers flowing into the seas, so much energy is lost, as if they ended in waterfalls with a height of 240 meters, since the osmotic pressure of the sea water exceeds 2.4 x 10^6 Pa (24 atm).

Amur the river most abounding in water in considered region. The average discharge of water in its mouth 12.8-11.4 m^3/s. Resources of energy of this river are huge. But so the river Amur runs into shallow Amur liman between island Sakhalin and continent at building there to power station of a point of a water fence of fresh water and not diluted sea water would be carried on the big distance.

Estimations of potentials of energy of gradients of salinity of some large rivers flowing into Okhotsk Sea are resulted in the Table 1.

Tab. 1: Energy potential SGE in the mouths of the rivers flowing into Okhotsk Sea

The river	Area of the river basin, km^2	Rate of the flow, m^3/s	Average power, MW
Penzhina	73500	680	1514
Uda	61300	510	1135
Okhota	19100	200	445.2
Poronay	7990	120	267.1

For the largest rivers of the Primorsky krai (Primorye) flowing into the Sea of Japan, the energy potential was assessed (Fig. 1) (Knyazhev, 2010). The total energy potential in the estuaries of the rivers will be 1.5 x 10^3 MW, while theoretically possible annual energy production will amount to 4.25 x 10^7 MJ. Resources SGE in other areas of the Far East is much higher. The total runoff of the rivers of the Pacific Ocean basin is 1212 km^3 / year, which corresponds to the theoretical resources of the SGE about 2.7 x 10^9 MJ.

Several methods have been proposed for the conversion of EGS. This is primarily membrane methods of energy conversion using semipermeable osmotic membranes and ion-selective membranes (reverse electrodialysis), as well as energy conversion methods, in which the transfer of water molecules occurs through surfaces that separate the different phase states of solutions, etc.

The development of osmotic power plants, the testing of semipermeable membranes and small experimental power blocks was carried out in the USA, Israel, Italy, and Japan. And in November 2009 in Norway in Tofte, south of Oslo, the state-owned energy company Statkraft launched the world's first osmotic power plant, which generates energy by mixing sea and fresh water.

Reverse electrodialysis plants allow direct conversion of energy from salinity gradients to electrical energy. Research on the development and testing of reverse electrodialysis plants was conducted in the USA, Sweden and Israel.

In the Netherlands, on the dam Afsluitdijk separating the man-made lake IJsselmeer from the sea, a pilot RED-Stack installation operates. And in Trapani (Sicily), a prototype of the pilot installation of the REAPower (Reverse Electrodialysis Alternative Power) plant, which uses brines from evaporative ponds and seawater is tested.

The main element of the reverse electrodialysis installation is an electrodialysis battery, which is a stack of alternating anion and cation-exchange membranes placed between the electrodes. Solutions with different concentrations are fed into chambers formed by pairs of membranes and working frames, so that chambers with solutions of high and low concentrations alternate. The directional movement of ions from the chambers from a high concentration to the chambers with a low concentration leads to the accumulation of an electrical potential on the electrodes.

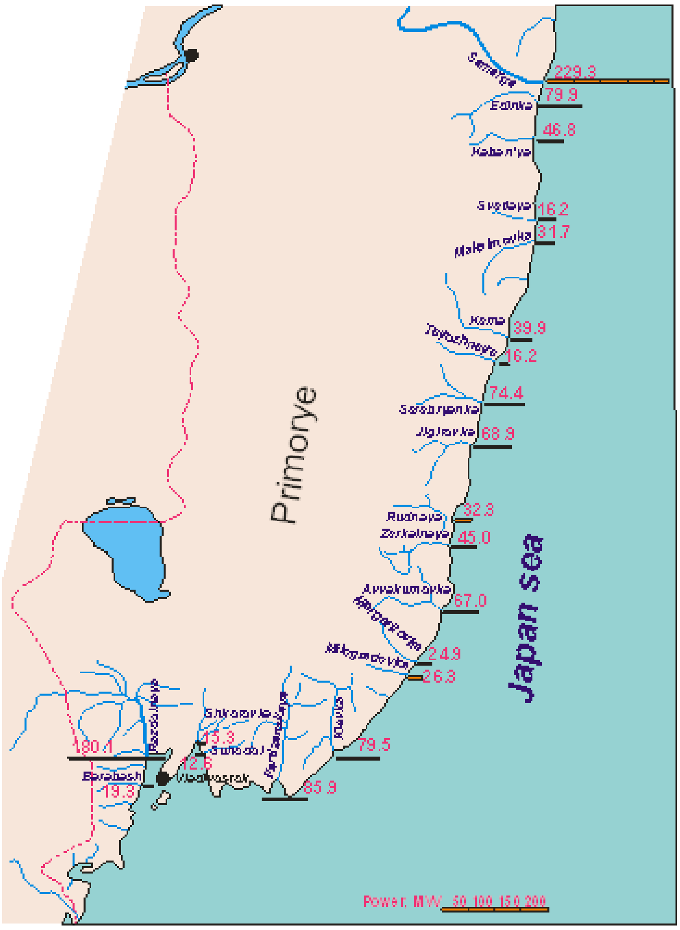

Fig. 1: SGE resourses rivers of Prymorye, Russia

In the laboratory of non-traditional energetics of IMTP FEB RAS, studies of the energy conversion of salinity gradients by the method of reverse electrodialysis were carried out. This method has a number of advantages and is most suitable for converting energy in the mouths of rivers flowing into the sea [2]. An experimental reverse electrodialysis installation was developed and created. Tests of the experimental installation in full-scale conditions on sea water from Alekseev Bay on the island of. Popov and fresh water from an artesian well confirmed that this method can be used to directly convert SGE into electricity.

2.3. Energy of the tides

In the Far East, the highest tides in the Penzhina Bay in the north of the Sea of Okhotsk, they reach 12.9 m there. In the Sea of Okhotsk, tides of a mixed type predominantly prevail, predominantly of the irregular diurnal one. Employees of the Ocean Energy Laboratory together with specialists from Moscow and Leningrad, together with the creator of the first in the country Kislogubskaya TPS (Tidal Power Station) L.B. Bernshtein from the Institute "Hydroproject" carried out work on the investigation of tidal regimes in the Penzhina Bay and in the Tugur Bay, proposed preliminary TPS projects. Expeditions were made to the Tugur Bay and the Penzhinskaya Bay to measure tidal sea level fluctuations (Fig. 2-Fig. 4).

According to the results of these studies, the energy resources of the tides in the Okhotsk Sea are the following potential integral values: the energy production of a tidal power plant in the Tugur Bay is estimated at about 6.8 x 10^{10} MJ / year, which corresponds to a power of more than 2000 MW; the energy production of a tidal power plant in the Penzhina Bay is estimated at about 6.8 x 10^{11} MJ / year, which corresponds to a capacity of more than 20 000 MW. Since such an amount of energy could not be used by the nearest consumers, it was proposed to export electricity to neighboring countries - Japan and China.

Fig. 2: Penzhina Bay, Cape Sredniy, loading the expedition on the vessel at low tide

a) b)

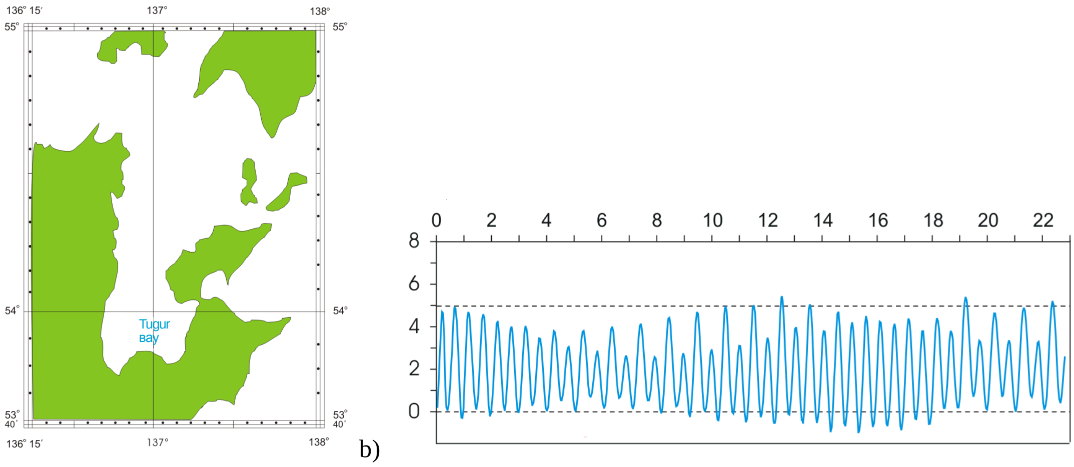

Fig. 3: a) Map of the Tugur Bay, b) Tidal level fluctuations. Tugur Bay. 5 - 28 August 1981 y.

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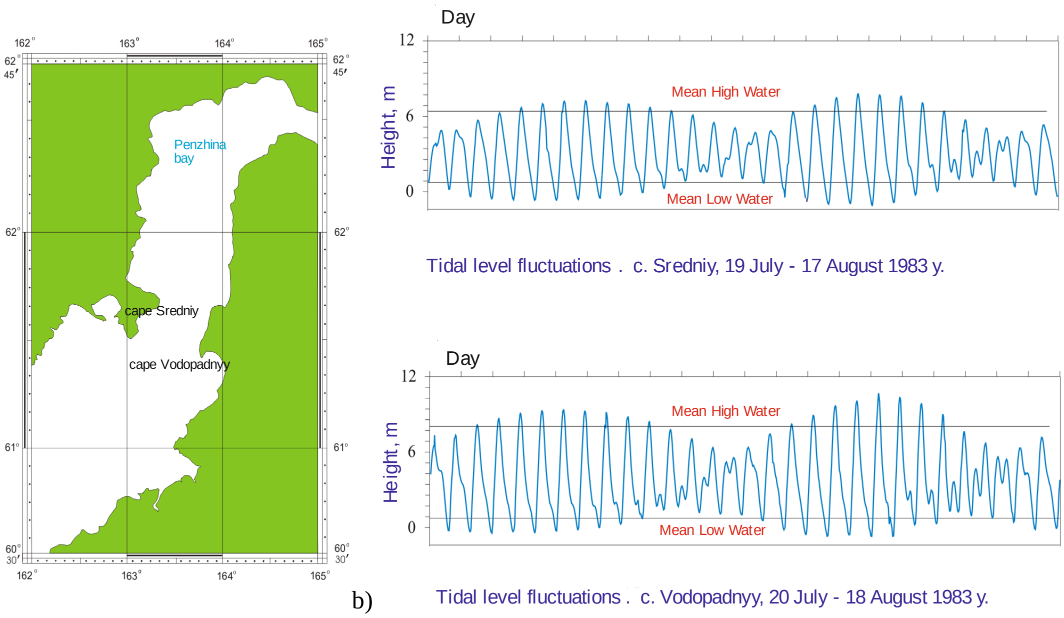

Fig. 4: a) Map of the Penzhina Bay, b) Tidal level fluctuations. Penzhina Bay

2.4. Current energy

Near the Far Eastern coast of Russia, tidal currents in narrow areas have speeds sufficient to effectively use them. In the Kurile Straits and in the Shantar Islands, the speed of tidal currents is up to 3.5 m / sec. It is there that it is possible to install hydroturbines in the water column to convert the energy of tidal currents. The power of such stations can increase gradually, adding as necessary new turbines. In this they have an advantage over the dams of TPS, when creating, which require huge initial capital costs for the construction of dams.

2.5. Energy waves

In the laboratory of the energy of the ocean, the problems of conversion of wave energy, wave energy resources in the World Ocean were studied. Several designs of wave energy stations have been proposed and patented, which have greater efficiency and lower material intensity.

The energy resources of waves in the Far Eastern Seas are high (Sichkarev, Akulichev, 1989) in Tab. 2 and 3 show the values of the wave energy fluxes, renewable power and annual energy in these seas.

Tab. 2: Flows of wave energy of the Far East seas (kW/m)

The sea	Winter	Spring	Summer	Autumn	Average annual
Bering	58/411	43/351	26/411	54/465	45/465
Okhotsk	34/351	31/294	18/351	32/189	29/351
Japan	49/351	40/351	17/189	37/351	36/351

Tab. 3: Renewed capacity and annual energy of water area of the Far East seas

The sea	The area, $m^2, \cdot 10^{12}$	Flows of wave energy (kW/m)	Renewed power, W, 10^{11}	Annual energy, J, $\cdot 10^{18}$
Bering	2.30	45	1,9	6,00
Okhotsk	1,59	29	1,01	3,19
Japan	0,98	36	0,71	2,24

2.6. Wind energy

Wind energy can be used not only on the sea, but also on land. And it was on land this source of energy was originally started to be exploited for technological purposes. As a result, significant progress has been made in the world in wind energy. In developed and developing countries, many wind turbines have been installed. As a result, in densely populated Europe there are almost no places to install large-capacity wind turbines. Therefore, and also because the resources of wind energy above the ocean surface considerably exceed them above the land, more and larger wind farms are installed on the sea shelf.

The coastal areas of the Far East have huge resources of wind energy; most of them belong to areas with winds of strong and medium intensity. According to experts in Russia, about 30% of the economic potential of wind energy is concentrated in the Far East. The advantage of using wind energy in these areas is that the maximum average speed here falls on autumn and winter - the periods of the greatest need for electricity and heat. The resources of wind energy over the water areas of the Far Eastern seas are much higher.

2.7. Solar energy

Primorsky Krai belongs to the regions of the Russian Far East and the whole of Russia, where it is advisable to use solar energy for energy supply purposes. The average number of sunny days per year for the Primorsky Kray is 310, with a sunshine duration of more than 2000 hours. Moreover, there are areas where the number of days without the sun is only 26 per year; the duration of sunshine is 2,494 hours. On the northern coast, the duration of sunshine is 1900 ... 2100 hours, on the southern coast the duration of sunshine is 2000 ... 2200 hours.

In general, the power input of solar energy to the territory of Primorsky Krai is about 30 billion kW. The practical resources of solar energy, taking into account environmental and other limitations, achieve: when receiving only thermal energy - 16 million kW; when receiving only electric energy - 4.9 million kW (Fig.5).

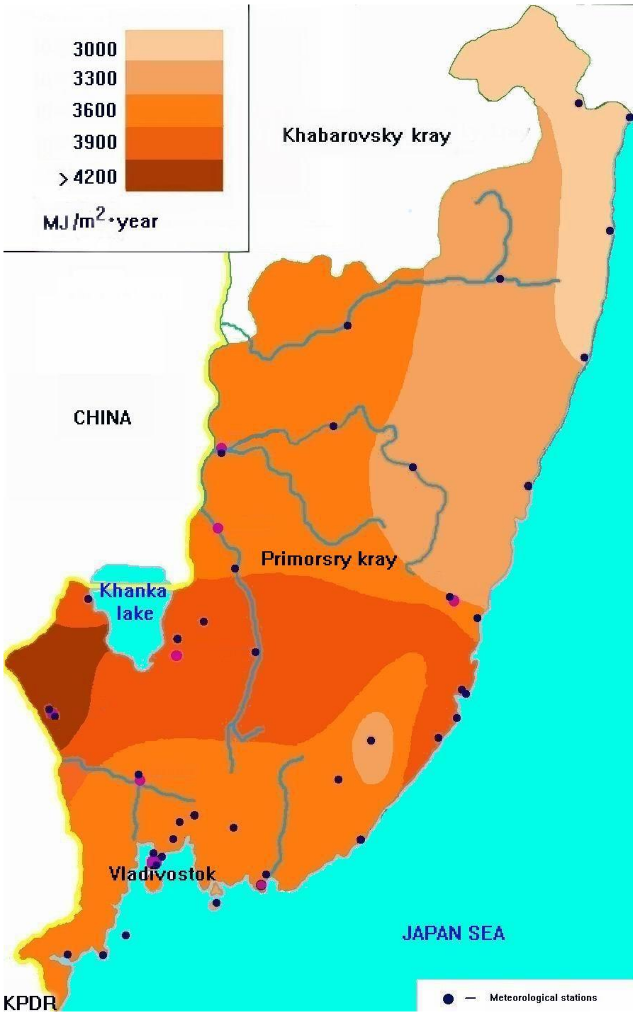

Fig. 5: Solar energy resources of Primosky kray

3. The system of energy supply of promising aquaculture complexes

The system of autonomous power supply of the long-shore factory of an aquaculture from renewed sources on an island of Popov is offered (Fig.6). The design of an experimental power system is fulfilled taking into account local natural settings and long-term meteorological and hydrological measurements for all-the-year-round providing of flow processes. Heat, cold and electricity ensure department of cultivation and department of deep rehash of aquatic organisms.

An autonomous automatic plantation (Fig.7) on the deep-water shelf with remote dispatching control and control, a wave electro-pneumatic installation and a system of buoyancy, aeration and lifting devices that provide long-term processes are developed. Remote dispatch control over the biological and technological parameters of plantations and depth change control excludes diving operations.

The technical project of a specialized semisubmersible vessel-dock of service of marine plantations develops. The vessel will effect installation and removal of sectors of plantations and will handle a crop.

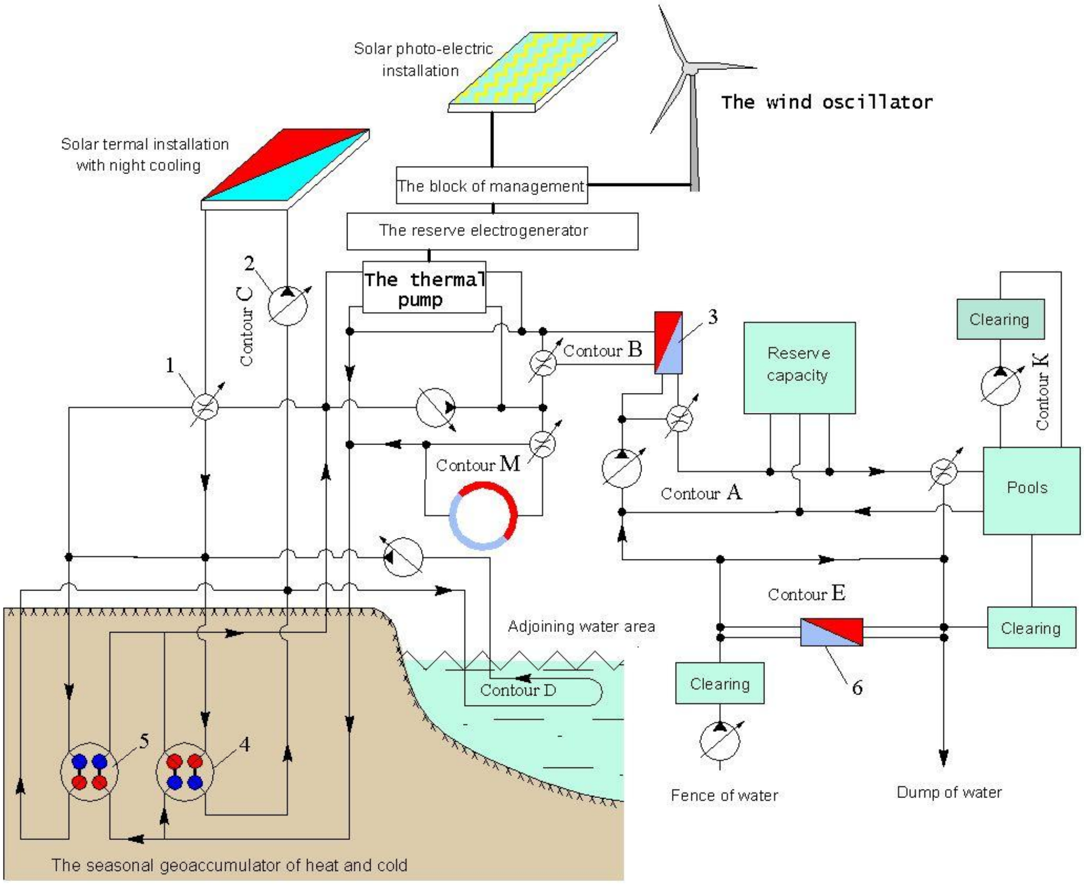

Fig. 6: The system of autonomous power supply of the long-shore factory of an aquaculture from renewed sources on an island of Popov. 1 - the managing valve; 2 - the pump circulating; 3 - the exchanger; 4 - probes of sector of heating; 5- probes of sector of refrigeration.

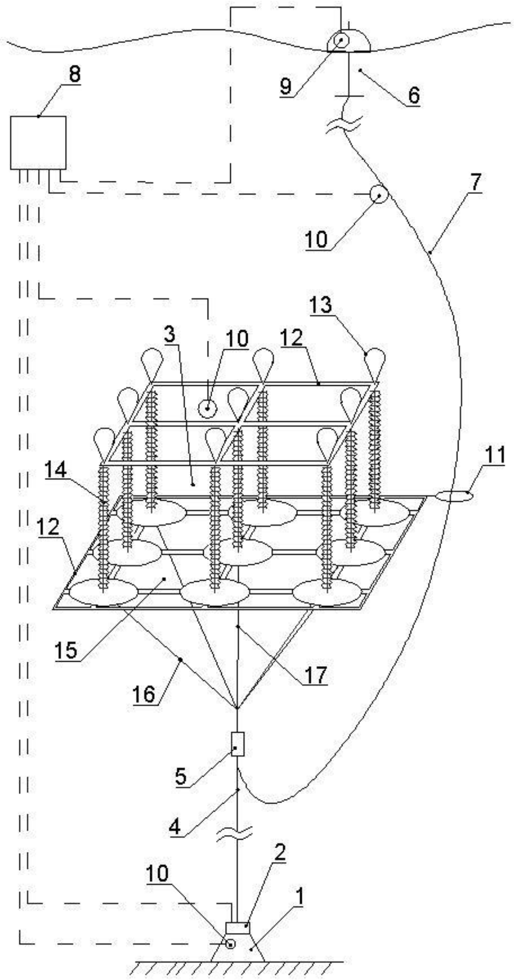

Fig. 7: Plantation Schemes on the Deep-water Shelf

1-bottom anchor; 2 - electric cable winch; 3 - platform; 4 - anchor cable-rope; 5 - automatic mechanical spring-loaded rod air valve; 6 - wave energy device; 7 - a cable-cable with the air pipeline; 8 - automatic program control and control unit with dispatching satellite communication; 9 - a set of sensors: battery charge, air pressure in the pontoon and the height of surface waves; 10 - set of depth, light, temperature, salinity, oxygen content and water flow rate; 11 - rigid loop; 12 - rigid grating; 13 - flexible floats; 14 - collector cables with hydrobionts; 15 - rigid lattice of hollow tubes; 16 - flexible braces; 17 - a cable-cable with the air pipeline; 18 - air lift pick-up; 19 - cable rope with air line and air-lift pipe.

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