ECONOMICS OF WAVE POWER PRODUCTION

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Summary

The total power of wind waves that can be used is estimated to be 2.7 billion kW. This is about the same figure as the power of the whole world power plants. The most developed countries of Europe, Asia and America demand in electric power can be covered by 20% only using coastal wind waves.

Wind wave power is renewable, easy to predict, environmentally benign. Use of wave energy does not produce wastes, does not need land estrangement and decreases expenses for coastline protection.

Wind wave energy has also a number of disadvantages that withhold its wide usage. First, is the instability of wave power and therefore impossibility to match the energy demand of customers. Second are problems of placing and fixing wave power devices offshore, problems of energy transmission to the customer, problems of stability in storm conditions, corrosion and sea-crust prevention, that are possible in aggressive sea medium.

There are lots of different proposals concerned with wave energy utilization including electricity production for it’s supply into an existing power system, supply of isolated power consumers, recharge of batteries and gas-cylinders, air liquefaction, sea water desalination, upwelling of deep ocean water to the surface, supply of sea platforms with desalted waters. Wind wave power devices may fortunately combine functions of levees and dams.

Economic feasibility of wave power devices are in general still lower than of conventional power plants. However WPD appear competitive for autonomous consumers using diesel engines powered with imported diesel fuel.

1. Economic Feasibility of Wave Power Devices

During the first period of intensive R&D in wave energy extraction (1973-1976) emphasis was given to gaining experience in design and construction of wave power devices (WPD) and didn't focus on relevant economical problems. But even preliminary assessments done at that time highlighted that the cost of power produced in these first WPD projects was higher than the power produced by conventional power plants (especially when such calculations did not take into consideration environmental aspects of power production). Results of such assessments differed significantly, the lower values being provided by project’s authors themselves.

In 1975 calculated specific cost of WPD in some projects in Great Britain ranged from \$300 to \$1200 for installed kW. In 1979 the Energy Technology Support Unit (Great Britain) predicted another figures ranging from \$8000 to \$18 000 for 1 kW installed. The cost of energy produced by the first WPD was \$0.42-1.05 kWh^{-1}, much more than cost of power produced by conventional power plants. Moreover the projects developed at that time were aimed at providing energy for whole countries or even regions and hence demanding exorbitant capital costs. For example, the cost of a project suggested by S. Solter (Great Britain) was estimated to be equal to several GDP of this wealthy country.

In late 70^{th} the oil prices dropped substantially and the interest in wave power production decreased. Many national wave power R&D programs were pruned. Only a few scientists and engineers in Japan - one of the first countries to start wave energy utilization, in 1976 predicted that the cost of wave energy could be reduced in future down to \$0.03 kWh^{-1}, lower than the cost of power produced by thermal and nuclear power plants.

Today the industry gained experience not only in design and construction but also in operation of WPD. There have been defined the most effective types of wave power primary and secondary converters. Rapid development of WPD constructions led to energy cost reduction down to \$0.10-0.31 kWh^{-1} and for some constructions even less. For example in the project for Mauritius island the calculated cost of energy for a 5 MW WPD was \$0.085 kWh^{-1} and for a 20 MW WPD - \$0.068 kWh^{-1}.

The project of a WPD developed in Sweden is even more optimistic. In this project about 30 WPD units supply water to a high head turbine deployed on shore. Calculated cost of installed kW of this plant is about \$1260-2520 and cost of electricity some \$0.034 kWh^{-1}to be the cost of electricity produced by Swedish nuclear plants is \$0.037 kWh^{-1}.

As the world’s first industrial wave power plant (WPP) built in Norway which is using a sloped chute that contracts to the top, the electricity cost was \$0.084 kWh^{-1}, and for another plant, which is using an oscillating water pillar - about \$0.63 kWh^{-1}**.**

In spite of the fact that there is a tendency to decrease the specific cost of installed kW as well as the produced energy costs, these costs are still rather high in comparison with conventional power plants. When compared with the cheapest nuclear power plants the installed kW cost for a WPP is higher by a factor of 5-8, whereas the cost of electricity produced by a WPP is higher than for a nuclear plant by a factor of 6-9. There are also other assessments saying that for example for Russian conditions the cost of installed kW for a WPP and for a nuclear plant can be about equal.

The majority of experts presume that for autonomous customers who use for power production diesel engines with imported diesel fuel, utilization of WPP can be competitive. First this is valid for power provision of small islands or remote coastal regions, which are not connected to power grid.

In general, today there are not enough necessary data to make reliable predictions concerning WPP economics. According to existing projects the WPP are costly and therefore there are no existing demonstration installations which could provide data for scaling up for commercial scale installations. The cost of electricity produced by existing small scale WPP is up to now higher than for other types of power plants using renewable energy sources and usually is higher than $0.16 kWh^{-1}.

Below are listed some optimistic predictions of electricity cost produced by industrial scale WPP in different countries made by several national, international and private organizations. These predictions were made in 1994-1999. The following costs are levelized for March 2000 in

US$ kWh^{-1}:
Australia - 0.12;
Great Britain - 0.01-0.03;
The Netherlands - 0.11;
USA - 0.10-0.20;
Japan - 0.14-0.28.

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Biographical Sketches

Valeri V. Volshanik, Professor, Department of water power usage, Moscow State University of Civil Engineering, Russia

Born 14 November 1939, Moscow

1962 Graduated from the Moscow State University of Civil Engineering

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1962 up to now collaborator of the Moscow State University of Civil Engineering, starting from 1997 Professor at the Chair «Usage of hydraulic energy»

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Born 25 November 1938, Moscow

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