WAVE POWER PLANT ECONOMICAL VALUATION IN BALTIC SEA AT PRE FLEXIBILITY STAGE

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This article is about one of the alternative energy sources – free surface gravity waves, and their use. The potential of the waves and its transformation devices are considered as the main energy use impact factors. Aim of the work – cost-benefit assessment to do the tasks: assessment of wave potential, identification of conversion model and turbine and economic criteria taking into account wave and price variability. The article also includes a description of the theoretical valuation of the costs of the mentioned turbines power plant.

Key words: renewable energy, wave energy, wave propelled turbine, wave power plant, wave length, wave power, axial turbine.

1. INTORDUCTION

The 21st century is a period of hasty growth in world population, production and consumption of fossil fuels (FF). World population has risen approximately 10 times in the 1819-2019 period [1]. Such a population increase significantly influence on global energy demand. Consequently, total world energy consumption in the last 200 years, has risen about 22 times [2].

Accordingly to the World Energy Council calculations [3], the coal is the most abounding of the FF, which reserve is enough for about 130 years. However, the global climate change poses a problem for the use of energy and especially for the use of FF [4-6]. The global use of coal, oil and gas leads to a rapid growth in carbon dioxide emissions. Global energy-related CO_2 emissions raised up to 1.7% in 2018 to achieve a historic value of 33.1 Gt CO_2. It was the peak ratio of increase since 2013, and 70% higher than the average growth since 2010 [6]. Such CO_2 growth contributes to the greenhouse effect and global warming. Since the 1880's world temperature has increased by about 0.8° Celsius (1.4° Fahrenheit) [7], as a result observations show a significant increase in the level of natural disasters and imbalance of different water states. Summing up, greenhouse gas emissions need to be controlled, and in a world of growing energy demand, renewable energy sources (RES) look like to be the best key of solution.

Nowadays the European Union (EU) has had a main role in the development of RES. For several years the EU has been accomplished to tackling climate change due to main European policies such as the Renewable Directive 2009/28/EC, Renewables energy directive (2018/2001), the Energy Efficiency Directive 2012/27/EU, Paris Agreement, etc. The EU is now committed to decreasing greenhouse gas emissions to 80-95% below 1990 levels by 2050 [5].

As a result, renewable energy has become the top priority in most developed and some developing countries. Accordingly to Renewable Energy Statistics [3], the quantity of renewable energy raised overall by 64.0 % between 2007 and 2019, equivalent to an average increase of 5.1 % per year. The most significant source in the EU-28 is wood and other solid biofuels. The next most important contributors to the renewable energy are wind and hydro power. Biogas, liquid biofuels and solar energy make up 7.4%, 6.7% and 6.4%, respectively, of the total share of EU-28 renewable energy produced in 2017. There are currently low levels of tide, wave and ocean energy production. However, the wave energy is promising energy source. It has the highest potential in terms of energy production, which makes it more interesting to investigate.

Wave energy has the several important advantages, comparing to solar and wind energy. Firstly, waves have a higher energy density [8-9]. Secondly, the wave energy is predictable one to two days ahead, because satellites can amount waves in the ocean, which will subsequently affect devices around the coast. This predictability will afford a smaller margin than is often required to support more volatile RES. Thirdly, wave energy does not require land area, driveways and devices to collect energy of a smaller size than devices for wind power.

Wave energy is one of RES, which is the untapped resource and currently is at an early stage of development [8-9]. It is estimated, that global wave power potential is equal approximately 1 TW, which is enormous and impressive value. Furthermore, world's potential is 10000-15000 TWh per year [8]. This is nearly the same as the economic potential in the range of wind and hydropower in the world. However, other scientists who have studied the potential of surface water gravity waves in the world have estimated from 8,000 TWh/year till 80,000 TWh/year [10]. Accordingly to Ocean Energy Statistics report of 2018 [11], Europe occupies a leading position in wave energy installation, which is equal to 11.3 MW.

There is a wide range of wave energy technologies. Each technology uses different solutions to absorb energy from waves, and can be applied depending on the water depth and on the location [8, 12-14]. In recent years, various onshore and offshore projects have been developed, including the Islay plant (Scotland) and the Pico Island plant (Portugal) [12, 15]. Continuing the investigation of the wave energy, many countries have seen some development in the planning, installation, and operation of wave energy converters (WEC). Although the amount of WEC is still at the Research and Development (R&D) stage. There is a very limited number of WEC devices that are suitable for a commercial pilot demonstration stage [16]. However, since 2008, the European Commission has invested over 190 M€ in ocean energy research and innovation through different projects, such as *Horizon 2020* and *Interreg* programmes [17]. Currently, plans and projects are being developed in the near future to get EU support and private investment for wave energy development [18]. With the rapid development of the technologies of WEC, the wave source will be able to meet parts the demand of energy.

The creation of new wave power plants (WPP) requires considerable material, financial and labor resources. Therefore, a feasibility study should be carried out to determine the proportion of funds for the construction of new WPP and to estimate the payback period of WPP.

The paper is focused on the free surface gravity waves and its potential in the Baltic Sea. Moreover, we developed and described the new turbine type - axial self-regulation blade hydrokinetic turbine that formed the basis of all calculations. Consequently, the main goal of our paper is to clarify the economic feasibility of the possible construction of marine WPP based on the developed hydrokinetic turbine.

2. WAVE POTENTIAL OF BALTIC SEA

According to [10, 18-19] the wave potential of the World Sea with some exclusions is 29 500 TWh/year. The Baltic Sea is the large sea, which is bounded by the coastlines of 9 countries. In the Baltic Sea alone, the potential is estimated to be 24 TWh [8]. It should be noticed, that global processes, such as global climate change, affect the Baltic Sea region, and as a result affects wave energy production in the region. The theoretical wave power reserve of the Baltic Sea is calculated to be 1 GW [20]. EU Strategy for the Baltic Sea was approved in 2009 [21]. The aim of this Strategy is to make the area of Baltic Sea more environmental, energy-generative, attractive and safe.

The potential of the Baltic Sea is actively studied despite the fact that there are more successful aquatories in the world. For instance scientists Soomere and Eelsalu [23] have described a study of both the theoretical amount of wave energy and its practically available part in a medium-depth aquatorium on the Baltic Sea's East coast. The 38-year average wave power is 1.5 kW/m, but in some places it reaches 2.55 kW/m, in the Gulf of Finland and in the Gulf of Riga – 0.7 kW/m. The most important factor and their conclusion is that this water area has an uneven distribution of wave energy during the year. The visualization of the medium depth wave power of the Baltic coast is shown in Fig. 1.

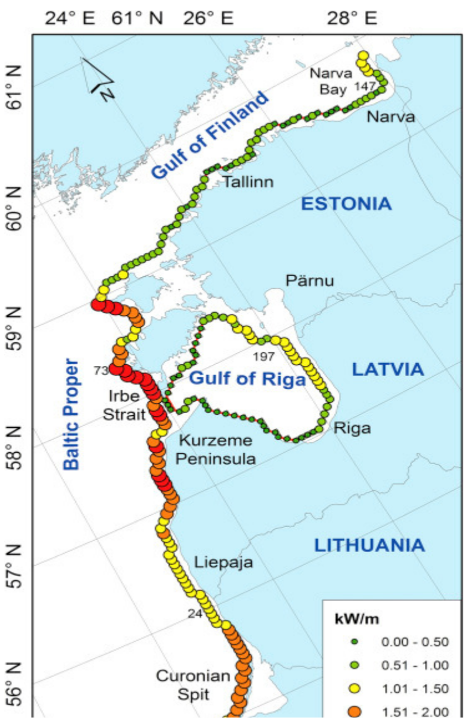

Fig. 1. Visualization of the medium depth wave power of the Baltic coasts after Tarmo Soomere and Maris Eelsalu [19].

The nodal points shown are 3 nautical miles apart. Results of specific wave power have been produced from 37 year period initial data. Unlevel specific wave power results shown depend on the distance of wave propagation and depth at the nodes. To get more accurate wave power data the exploration should be lead to deep water direction.

There are different methods for determining the potential of waves [19, 22-23]. These methods have gaps [24]. To mitigate the weaknesses of the above methods in the wave power estimation, we propose a Wave Energy Direction Baseline Projection (WEDBP) method [24] whose initial calculations correspond to the classic irregular wave calculations. The method differs from others by selecting basic base directions +/- 22.5^o and by these sectors the specific power and specific energy of the node points are summed. Then there are polygons around the node points that cover the area of the aquatorium, if it is necessary to mathematically model additional node points and sum up the results [24]. With WEDBP method it is possible to cover a large area of the aquatorium with a small amount of nodal number and therefore input data.

Input data used for energy, power and wavelength calculations are significant wave height (H_{si} or *swh*), wave period (T_e) and mean wave direction (*mwd*) [11].

Energy calculations were performed by algorithm of the WEDBP method:
From the energy spectrum by integrating in the frequency range [0; ∞] calculate the average wavelength energy density of J_{vid} in the area of 1m^2 [25]:

$$J_{vid} = \rho g \int_0^\infty S(f)df = \rho \cdot g \cdot m_o = \frac{\rho \cdot g \cdot H_{m0}^2}{16} = \frac{\rho \cdot g \cdot H_S^2}{16} \qquad (1)$$

where p is Seawater density, kg/m^3; g is Free fall acceleration, m/s^2; f is wave frequency (Hz); $S\ (f)$ is wave energy spectrum function; m_0 is 0-th spectral moment; $H_{m0} = H_s$ is characteristic wave height, m.

1. In the Baltic Sea Area "A" perpendicular to 8 traditional wind and wave directions (PV_{xx}, where: xx = (N; NE; E; SE; S; SW; W and NW) set the lines perpendicular to those directions.

Thus, summing the wave direction of the energy (1) over time interval Δt in each of the node points by sector, the wave energy of non-duplicate directions is counted:

$$\dot{E}n(Km, PV_{XX}) = \Delta t \cdot \frac{\rho g^2}{64\pi} \sum_{i=1}^{n} IF(mwd_i, PV_{XX,min}, PV_{XX,max})(T_{ei}(H_{si})^2) \qquad (2)$$

where PV_{xxmin} is minimum limit for basic PV_{xx} sector; PV_{xxmax} is maximum limit for PV_{xx} sector; H_{si} is significant wave height in the i-th time interval, m; $T_{e\,i}$ is average energy period of wave energy density spectrum, s.

The annual wave energy potential of the control point P$_m$ for a 1m wide wave $\dot{E}_g$ is calculated as follows:

$$\dot{E}_{g,m,xx,yy} = \sum_{n=1}^{12} (E_{n,,m,xx,yy}), \qquad (3)$$

2. Integrating the direction of the reference line control points into the corresponding energy by integrating its specific energy function within the distance projection. Thus, the integration process is reduced to the use of trapezoidal method [26], which is as follows:

$$E_{xxyy}(K1, K5) = \sum_{m=1}^{m+1=5} E\ (\Delta\mathrm{L}(m, m+1)_{xx} = \sum_{m=1}^{m+1=5} \frac{\dot{\mathrm{E}}n(K_m) + \dot{\mathrm{E}}_n(K_m+1)}{2} \cdot \Delta\mathrm{L}(m, m+1)_{xx} \tag{4}$$

where m is node point $P_{m,xx}$ serial number (1, 2, 3, 4, 5, 7); $\Delta L\ (m,\ m+1)$ is the distances (m) between these point projections on the base line, taking into account the coordinates of the azimuth and control points of the baselines.

3. Knowing the potential of wave energy in the control area where control points P1 are located; P2; P3; P4; P5 and P7, which are marked by the projections of the checkpoints on the base lines of the direction (Fig.2) and knowing that the control area forms a significant, but not all, part of the analysed area and knowing that the distribution of wave energy in time and space is dispersed homogeneously, it is possible to estimate the amount of PV_{xx} energy for each increasing proportionally the ratio of the direction of the reference line P_{nyy} and the sum of the respective projection sections of the node points L (P1, P5)$_{yy}$

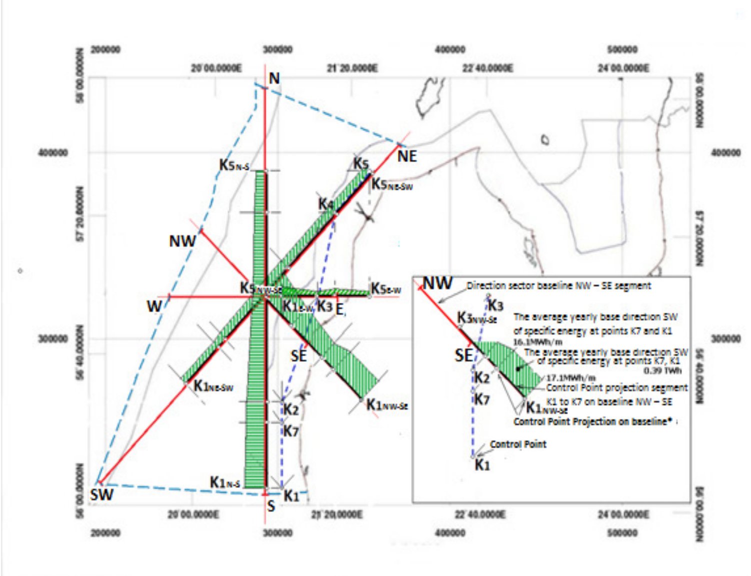

Fig. 2. Wave annual average energy projections in the Baltic Sea area “A” [24, 27].

4. As result of calculation of any aquqtorie’s potential the total monthly/annual wave potential is the sum of 8 potentials.

In the Baltic Sea Latvia's Exclusive Economic Zone (EEZ) 7 node points were selected, for which we received input data from Danish Meteorology Institute (DMI) and a number of calculations were made for five years (Table 1).

Table 1

Schedule of Baltic Sea Latvian EEZ wave potential calculations

Names of calculations	Node points						
	P1	P2	P3	P4	P5	P6	P7
$E_{monthly}$ depending from H_{si}/T_e	2010 – 2014	2010 – 2014	2010 – 2014	2010 – 2014	2010 – 2014	2010 – 2014	2010– 2014
$E_{monthly}$ depending from H_{si}/T_e	2010– 2014	2010– 2014	2010– 2014	2010– 2014	2010– 2014	2010 – 2014	2010– 2014
$E_{time\ distribution}$						2010	
$P_{specific}$ depending from H_{si}	2010 – 2014	2010 – 2014	2010 – 2014	2010 – 2014	2010 – 2014	2010 – 2014	2010 – 2014
$P_{wave\ specific}$ time distribution	2010 – 2014						
Distribution of waves by λ intervals	2011						
$E_{specific}$ P5 distr. by *mwd* & month					2010 – 2014	2010 – 2014	2010 – 2014
$E_{specific}$ P5 distr. by month					2010		
$E_{specific}$ P5, P6, P7 distr. by month					2010 – 2014	2010 – 2014	2010 – 2014
$E_{specific}$ P6 distr. by *mwd* & month					2010 – 2014	2010 – 2014	2010 – 2014
$E_{specific}$ P7 distr. by *mwd* & month					2010 – 2014	2010 – 2014	2010– 2014

where $E_{specific}$ monthly is distribution of wave energy potential by month, kWh; $E_{specific}$ time distribution is wave energy distribution by time kWh/m; $P_{specific}$ depending from H_{si} is wave power dependence from significant wave height, W/m, $P_{specific}$ time distribution is wave power distribution by time, W/m; λ is wavelength, m, $E_{specific}$ P5 distr. by *mwd* & month is specific wave energy distribution by mean wave direction and by month at node point No 5, kWh/m; $E_{specific}$ P5 distr. by month, is specific wave energy distribution by month at node point No 5, kWh/m, $E_{specific}$ P5, P6, P7 distr. by month is specific wave energy distribution by month at node point No 5, kWh/m; No 6 and No 7, $E_{specific}$ P6 distr. by *mwd* & month is specific wave energy distribution by mean wave direction and by month at node point No 6, kWh/m; $E_{specific}$ P7 distr. by *mwd* & month is specific wave energy distribution by mean wave direction and by month at node point No 7, kWh/m.

3. EQUIPMENT CHOICE

In cooperation with Riga Technical University, at least 108 current developments were considered. At the beginning totaly were considered more 109 installed and under development equipment [28]. Then where made classification of equipment according suitability of installation to onshore, nearshore and offshore. Then where selected type of equipment from point of view of options to elevate receiver and to position to mwd. Finally the axial turbine with vertical axis and self regulating blades (SAB) was choosen.

4. CONCEPT OF SELECTION TURBINE DIAMETERS

On Fig. 3 the new type of turbine, an axial self-regulating blade hydro-kinetic (ASRBHK) turbine, is presented. It was tested in laboratory conditions.

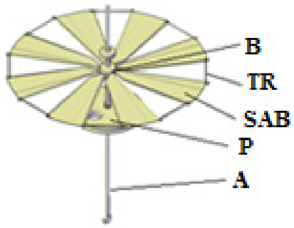

Fig. 3. ASRBHK turbine construction (B – bearing, TR – tensioning rubber, SAB – self-adjusting blade (SAB), P – pulley, A –axis) [29].

Various torqueses are formed on the ASRBHK turbine during its various phases and in the turbine wing positions. Turbine works more efficiently when the number of wave phases is as small as possible. Each wave has four phases. The smallest number of phases which crosses the turbine wing is two. For this reason, it is worth looking at the length of SAB depending on the wavelengths. Let's look at one of areas of the Baltic Sea's Latvian EEZ (for example with data of node point P1 in 2010) (Fig. 4).

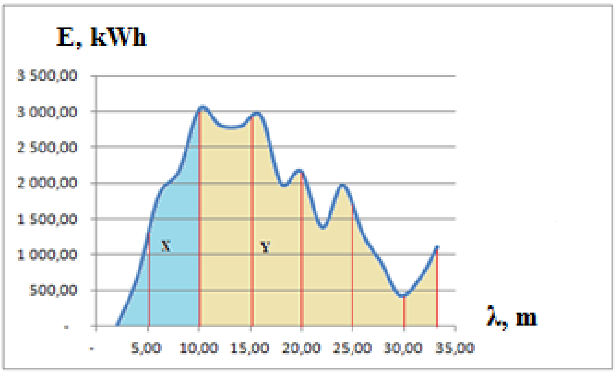

Fig. 4. Distribution wave energy at node point P1 2010 depending from λ/4 (m)

Fig.4 shows that enough wave energy will be in the area X where ¼ of the wavelength will be 10 m. This means that the maximal turbine diameter could be 20 m. Meanwhile the minimal diameter would determine some other parameters like drop of efficiency and/or too high costs. In the area Y shown in Fig. 4, the turbine of any diameter will work with partial wave power due it should be deepened in to avoid overloading.

5. TURBINE POWER CALCULATION

To determine turbine power, we combine and stack two methods – experimental to determine turbine model power and mathematical to determine industrial-sized turbine power. In order to find out the parameters of the turbine model, turbine models were made for which the shape of the self-adjusting blade was sub-optimized. The laboratory wave stand had the ability to change the wave parameters (*H* and *T*). In order to determine the capacity of an industrial-sized turbine, we looked at the specific power frequency of the potential P1 wave power plant in the Baltic Sea. This is essential for providing the turbine with optimum load. For the transition from the turbine model to the industrial size, let's use the Morozov’s equation [25] before creating a special relationship more suitable for this mechanism.

In order to identify how long the waves of particular average power last, we will create hourly statistics. For example, node point P1 2010 (Fig. 5).

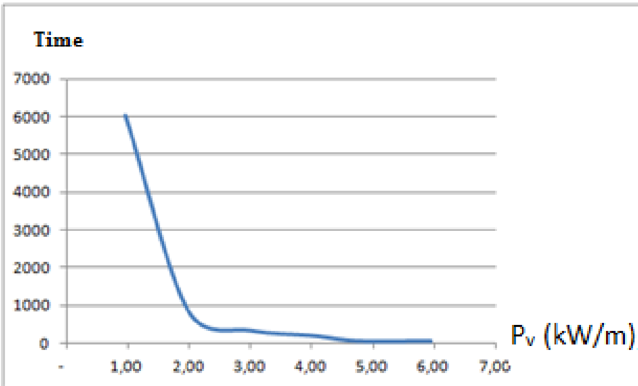

Fig. 5. Wave average hourly specific power P_v (kW/m) statistics at node point P1 (2010)

By optimizing the peculiar incoming energy of the mentioned node point, the result was – the optimum specific power is 1 kW/m.

The coefficient η_T is used to determine efficiency of transformation from wave energy to electricity and can be characterized by equitation (2):

$$\eta_T = \eta_V \times \eta_H \times \eta_P \times \eta_F \times \eta_L \times \eta_M \times \eta_E , \quad (5)$$

where η_V is kinetic energy distribution coefficient in volume; η_H is horizontal flow separation ratio (0.5); η_P is flow utilization factor for estimating the flow of the flow through the turbine (Beitz/Glauerts 0.5926) [30] ; η_F is form factor (π/4); η_L is turbine hydraulic efficiency; η_M is mechanical efficiency (bearing, seal 0.95); η_E is efficiency ratio of the electric generator (for calculations we will use 0.95).

Let Morozov's equation (6) describes the relationship of the known ASRBHK turbine T_1 model and geometric similar turbines T_n with diameter D_n (6):

$$\eta_{Ln} = (1 - (1 - \eta_{L1}) \times \sqrt[5]{\frac{D_1}{D_n}}, \tag{6}$$

where η_{Ln} is efficiency coefficient of a geometrically similar turbine; η_{L1} is efficiency ratio of known turbine; D_1 is diameter of known turbine (0.9 m); D_n is diameter of the geometrically similar turbine.

Assuming η_{T1} and η_{Tn} expressions based on equation (5), dividing both of these equations with each other and by deducing the same variables we will express them as equation (7):

$$\frac{\eta_{T1}}{\eta_{Tn}} = \frac{\eta_{L1}}{\eta_{Ln}} \tag{7}$$

From (7) known turbines η_{L1}:

$$\eta_{L1} = \frac{\eta_{T1}}{\eta_V \cdot \eta_H \cdot \eta_P \cdot \eta_F \cdot \eta_M \cdot \eta_E} \tag{8}$$

where all the values on the right of the equation are known. Thus, knowing η_{Ln}, η_{L1} and η_{T1} from the expression (8), the coefficient of utilization of the geometrically similar turbine η_{Tn} is calculated. Calculations of η_T for ASRBHK turbine of different diameters from 1 m to 30 m with step in 1 m were made.

Turbines utilization rate was estimated based on turbine (D = 0.9 m, P_w = 0.764 W/m only) parameters. That's mean – incoming power of turbine (D = 9.0 m) is only 0.08 kW, turbine (D = 15.0 m) is only 0.21 kW and turbine (D = 20.0 m) is only 0.38 kW. For more powerful waves, the turbine utilization factor will improve. For our further calculations we will use assumption, that average turbines utilization rates are appropriately D = 9.0 m – 0.25.

6. ECONOMIC ASPECTS

A. Forecasting of wave energy production

Price forecasting is the basis for solving a wide range of important problems for planning and managing the energy sector, and feasibility study of wave energy production is not an exception. A great number of methods from different modeling families are used for analyzes and planning questions [31]. Comprehensive reviews of pricing approaches are provided in the articles [31-33].

To analyse the feasibility of presented WPP, net present value (NPV) and payback period (PP) for planning period, T_p (in our case 34 years), should be estimated. In NPV criteria value assessment, the greatest difficulty is related to calculation of the net cash flow R_t, because of the change of the energy prices over time. In our case, the R_t (€) is calculated as follows:

$$R_t = P_{rat,t} \cdot \tau \cdot L_{WPP} \cdot k \cdot C_t \qquad (9)$$

where $P_{rat,t}$ is rated specific wave power for hour t, kW/m; τ is time step (1 hour); L_{WPP} is length of WPP, m; k is flow average utilization factor; C_t is predicted market price of electricity at hour t, (€/kWh).

In order to calculate NPV, it is necessary to describe changes in processes for many years ahead. This task leads to uncertainty and necessitates the use of the methods of the theory of stochastic processes. In our case we assume that electricity prices can be forecast by using the Fourier series and white noise. It should be pointed out that, the approach we use is only one of the possible approaches. The proof of its satisfactory accuracy and a more detailed description is given in our previous work [34]. 1.5% increase of the annual average price is assumed. Moreover, the rated specific wave power is estimated for one year and does not change during planning period.

B. The Methodology of Feasibility Studies

Commonly, energy planning issues are formulated in the form of profit maximization tasks. In this paper, we limit ourselves to using only the NPV [35]. The NPV could be formulated as optimisation task as follows:

$$NPV(T_p) \rightarrow max \qquad (10)$$

In our case we estimated two options of NPV:

1. Prosumer takes a credit in bank for WPP construction:

$$NPV(T_p) = -C_{invest} + \sum_{t=1}^{T_P} \frac{(R_t) - \left(\frac{C_{invest}}{T_p} + C_{loan,t} \cdot i_{cred}\right)}{(1+i_d)^t}, \qquad (11)$$

where C_{invest} is initial investments of WPP construction, €; t is planning year (1, 2, ... T_p=34); $C_{loan,t}$ is outstanding loan amount of year t, €; i_{cred} is credit rate, %; i_d is discount rate, the rate of return that could be earned on an investment in financial markets with a similar risk.

2. Prosumer does not take a loan:

$$NPV(T_p) = -C_{invest} + \sum_{t=1}^{T_p} \frac{R_t}{(1+i_d)^t} \qquad (12)$$

7. CASE STUDY AND RESULTS

A. Input information

In case study we considered wave potential of one sector (with parameters of node point P1 [24] of Latvian EEZ of the Baltic Sea. In this section the early feasibility study of WPP P1 sector is presented. We estimate the economic criteria of WPS construction, such as NPV of cash flow and PP. Moreover, one of the goals of the study is to determine the coefficient *k*, at which the PP of this project will be 10 years. The NPV is calculated for two alternatives: Alternative 1 presumes taking a loan; Alternative 2 entails no loan. As a result, 42 scenarios are reviewed.

The necessary input parameters and investment cost of P1 sector are displayed in Table 2. It should be mentioned that data of total costs of one set is assumption.

Table 2

Input parameters of WPP at sector P1 of the Baltic Sea

Specific wave power, $P_{rat.max}$, kW/m	Length of WPP, L_{WPP}, m	Costs of hydrokinetic turbine, €/turbine	Amount of turbines	Total investments of WPP, M€	Discount rate, %	Credit rate, %
7.67	19 400	15 000	2 156	32.33	4.0	2.6

Data of total costs of one set is assumption. Costs of one turbine were calculated on the basis of generators basis as comparison with common diesel generator price to kW x 3 [36], which appreciate generators underwater working conditions, anchoring/elevating device and network connection. Working hours per year at full capacity in fact should be less due power station will take some shape. Therefore in respect of *mwd* rose some energy will be shaded.

B. Results

The resulting NPV curves are shown in Fig. 6 – Fig. 7.

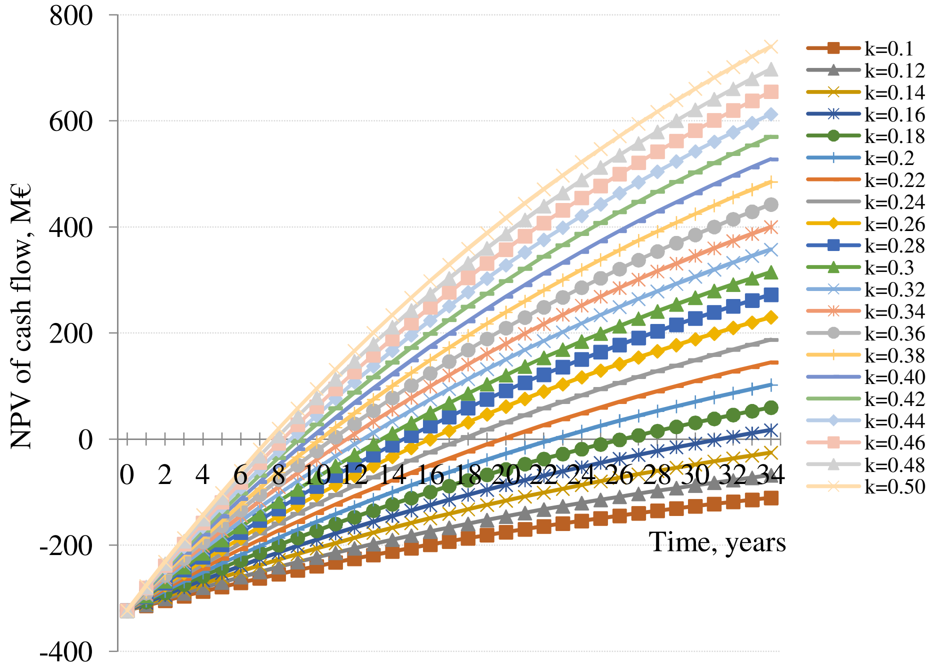

Fig. 6. NPV cash flow of P1 without loan.

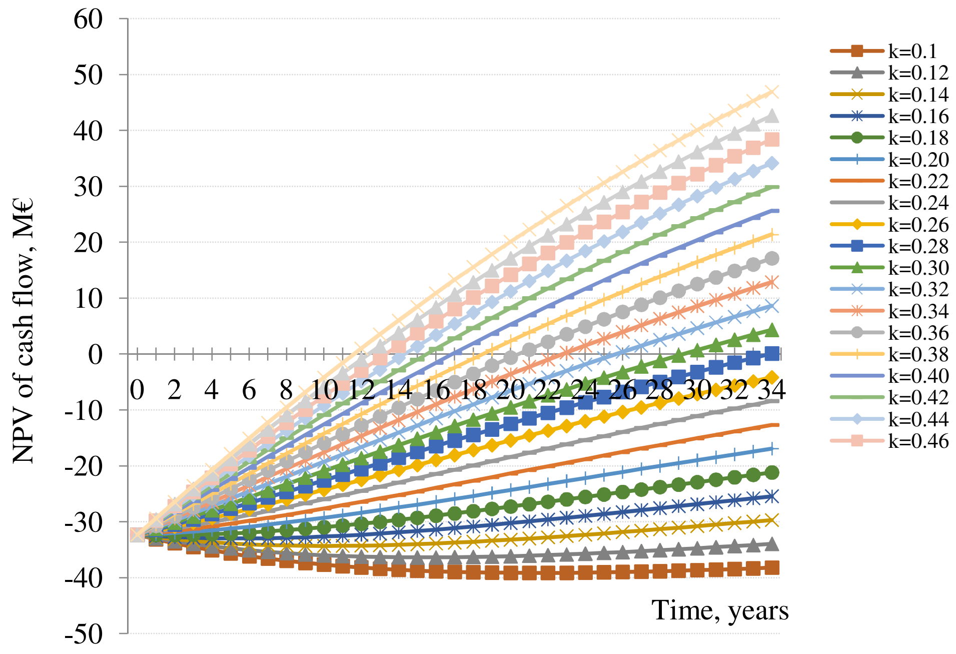

Fig.7. NPV cash flow of P1 with loan.

Based on the assumptions and reviewed scenarios, the PP of WPP P1 investment is varies from 7 years till more than 34 years. Analyzing the Alternative

1 of NPV, it is viewed that in order to achieve a plant payback of 10 years, the utilization coefficient should be no less than 0.34. As regards results of Fig. 7, wave average utilization factor should be more than 0.50.

It is also necessary to take into account that in calculations an average coefficient of wave utilization was adopted, in practice this coefficient will vary constantly depending on the, turbine load.

Therefore, one of the objectives of the future research will be to accurately determine the wave utilization factor and its effect on wave energy production and the payback of the wave energy technology.

8. CONCLUSIONS

1. The dynamics of energy consumption and the related climate change are encouraging the increased use of renewable resources.
2. Free surface gravity waves could become an important source of renewable energy.
3. Wave potential is being studied in the world, including the Baltic Sea.
4. The recommendations of binding standards should be more respected in order to assess the potential of waves more precisely.
5. More than 1,000 patents are registered worldwide for wave transformation.
6. The vertical axis turbine operates under laboratory conditions.
7. More accurate economic calculations require input from higher TRL and power plant sketch designs.
8. In order to achieve a payback time of 26 years without a credit in the Baltic Sea power plant with nodal point P1 parameters, the turbine must have a flow utilization factor of 0.18.

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PRIEKŠIZPĒTES STADIJAS EKONOMISKAIS NOVĒRTĒJUMS VIĻŅU SPĒKSTACIJAI BALTIJAS JŪRĀ

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Kopsavilkums

Šis raksts ir par vienu no alternatīvajiem enerģijas avotiem – brīvas virsmas gravitācijas viļņiem un to izmantošanu. Par galvenajiem enerģijas izmantošanas ietekmes faktoriem tiek uzskatīts viļņu potenciāls un tā pārveidošanas ierīču efektivitāte. Darba mērķi ir sekojoši: viļņu potenciāla novērtēšana, enerģijas pārveidošanas modeļa un turbīnas izvēle, kā arī ekonomisko kritēriju izvirzīšana, ņemot vērā viļņu un cenu mainīgumu. Rakstā iekļauts arī minētās turbīnu elektrostacijas izmaksu teorētiskā novērtējuma apraksts.