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IMPLEMENTATION OF PELAMIS WEC TECHNOLOGY FOR THE CRIMEA REGION CONDITIONS FOR ENERGY EFFICIENCY INCREASING

Був проаналізований потенціал відновлювальної енергетики України в цілому та Кримського півострову. В результаті аналіза була запропонована Pelamis технологія для вирішення нестачі електрики в Криму.

Проанализирован потенциал возобновляемой энергетики Украины в целом и Крымского полуострова. В результате анализа предложена Pelamis технология для решения проблемы нестачи электричества в Крыму.

The renewable energy potential of Ukraine and Crimea peninsula were analysed. As a result of this analysis Pelamis WES technology was offered for the solution of the problem of the electricity shortage in the Crimea.

The problem of mineral resources is one of the most pressing today. It is stated clearly, that the energy potential of traditional power recourses decreases day by day. Upon this Ukraine, as many other European countries, is dependent on fuel and power resources import and it has great influence on state economy. To solve such problems renewable and environment's friendly power recourses usage is a valuable option. And for Ukraine the installations of wind energy, solar energy, bioenergetics, hydro energy, geothermal energy have the best potential. Most elaborated region in terms of using renewable energy is the southern region of Ukraine, the Crimea in particular.

Ukraine consumes natural gas heavily (with imports from Russia accounting for as much as 70.0% of the total consumption), while producing renewable energy in negligible amounts comparatively to other European countries that also experience a lack of own mineral resources. Energy generation from renewable/alternative sources became a hot topic in Ukraine during the recent months. Development of alternative energy sources looks especially urgent if one considers the existing potential. According to the local official sources, Ukraine's renewable energy potential falls within 12.5-22.0 million tons of oil equivalent range (see the table below). On the other hand, a recent study by M.P. de Wit and A.P.C. Faaij (the Netherlands) estimates Ukraine's biomass energy potential at as high as 119.4m toe corresponding to 86.9% of the current total consumption. The potential of Ukranian renewable energy resources we can see on the table 1.

Tab. 1 The potential of Ukranian renewable energy resources

Source	Potential of resources		
	Full potential	Technical potential	Economical expedient potential
Solar energy, MWh/year	$718{,}4 \cdot 10^9$	$345{,}1 \cdot 10^9$	$53{,}8 \cdot 10^9$
Small river, MWh/year	$12{,}501 \cdot 10^6$	$8{,}252 \cdot 10^6$	$3{,}747 \cdot 10^6$
Wind power, MWh/year	1,88	0,52	
Peat, MWh/year	6801		2941
Heat of the ground, MWh/year	$1{,}575 \cdot 10^6$	$1{,}125 \cdot 10^6$	$0{,}106 \cdot 10^6$
Mining gases, MWh/year		$9{,}885 \cdot 10^6$	

Entrails of the earth, MWh/year	$17{,}365 \cdot 10^6$		

Crimea peninsula is mostly a recreational zone, a small part is allotted for agriculture (vineyards, fruit gardens, etc.). The main problem of the peninsula is electricity shortage. But the Crimea have big potential of renewable sources (diagram 1).

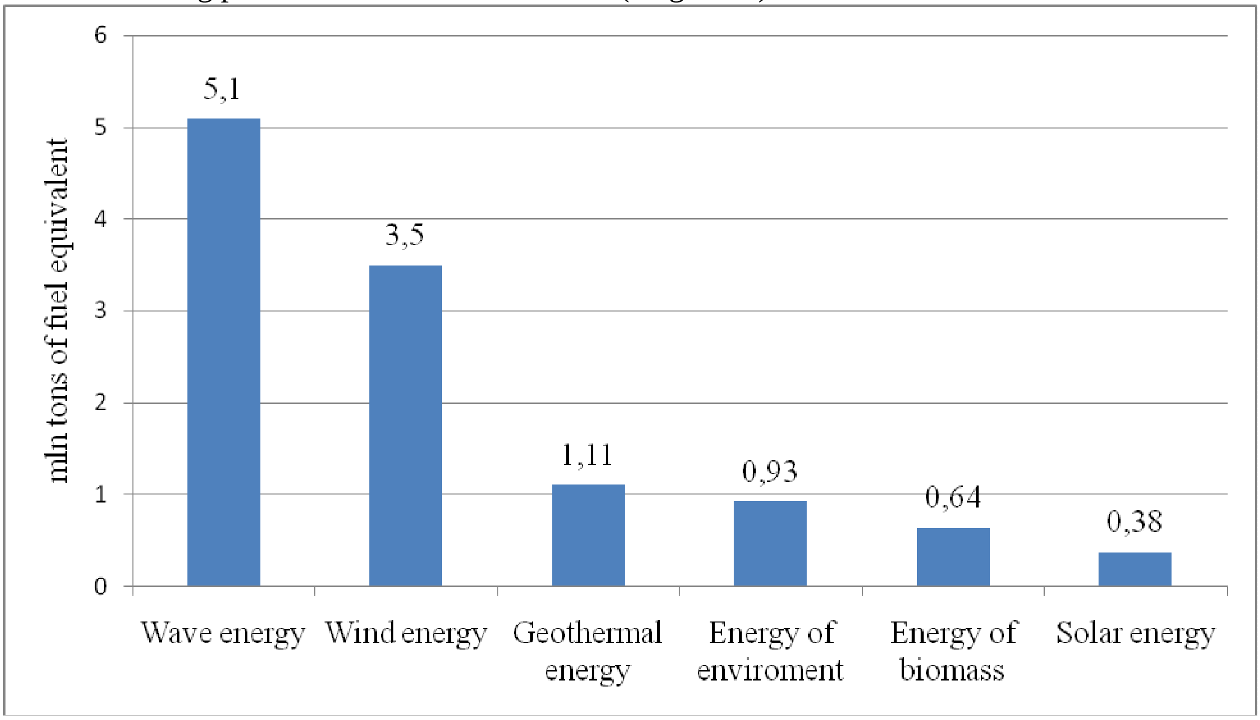

Diagram 1. The potential of renewable energy resources in AR Crimea, mln tons of fuel equivalent

As one of the possible solutions of this problem it wave energy transformation device (invention of Scottish company Pelamis Wave Power) is suggested, the official name of which is Pelamis Wave Energy Converter. The usage of the wave energy depends on with wind activity of the region. That’s why it’s important to investigate climatic conditions of the region zones of higer wind activity.

Most Crimea region climate zones are characterized by moderate temperate. The highest average month temperature in July reaches 27°C. The highest January average temperature is about -4°C. Most powerful winds are inherent to the Black Sea and the Sea of Azov shores and in highlands.

Waves are generated by the passage of wind across the surface of the sea. Energy is transferred from the wind to the waves. Waves travel vast distances across the ocean and at great speed and the energy is concentrated near the water surface. The energy within a wave is proportional to the square of the wave height. Therefore a two-meter high wave has four times the power of a one-meter high wave. The Pelamis absorbs the energy of ocean waves and converts it into electricity.

PWP’s (Pelamis wave power) full scale prototype machine was tested at the European Marine Energy Centre between 2004 and 2007. The prototype was the world’s first commercial scale wave energy converter to generate electricity to a national grid from offshore waves. It was launched in early 2004 and first installed at EMEC in August 2004 following a series of sea trials in the North Sea.

In 2006 the prototype was upgraded to the same specification as the production machines used in the Aguçadoura project. Further sea trials were carried out on the upgraded machine before it was reinstalled at the EMEC site in March 2007. The machine then completed a further extensive phase of testing, meeting a large number of critical test objectives.

From a distance, they look nothing more than thin red lines on the horizon. The Pelamis P-750 Wave Energy Converter is a result of intensive testing, modelling and development by Pelamis Wave Power, officially known as Ocean Power Delivery. Each segment measures 120m long and 3.5m wide, and weighs 750 tons when fully ballasted.

The machine is a semi-submerged, articulated structure composed of cylindrical sections linked by hinged joints. The wave-induced motion of these joints is resisted by hydraulic rams, which pump high-pressure oil through hydraulic motors via smoothing accumulators. The hydraulic motors drive electrical generators to produce electricity. Power from all the joints is fed down a single umbilical cable to a junction on the sea bed. Several devices can be connected together and linked to the shore through a single seabed cable. A novel joint configuration is used to induce a tuneable, cross-coupled resonant response, which greatly increases power capture in small seas. Control of the restraint applied to the joints allows this resonant response to be ‘turned-up’ in small seas where capture efficiency must be maximised or ‘turned-down’ to limit loads and motions in survival conditions. The machine is held in the position by a mooring system, comprising of a combination of floats and weights which prevent the mooring cables become taut. It maintains enough restraint to keep the Pelamis positioned but allows the machine to swing head on to the oncoming waves. Reference is achieved by spanning successive wave crests. The Pelamis is designed to be moored in waters approximately 50-70m in depth (typically 5-10km from the shore) where the high energy levels found in deep swell waves can be accessed. The design of the Pelamis has been independently verified by WS Atkins according to (DNV) offshore codes and standards.

According to present prognosis energy consumption in the Crimea grew to 1500 MW, therefore development of local electrical power installations becomes even more necessary. Dynamics of Crimea economics development especially in tourist sphere will most likely lead the amount of electricity usage to getting even in summer and winter periods. The investment supposedly will increase job offers, which is also an important argument for renewable energy drift.

Pelamis is designed in a way, that minimizes impact on the costal environment. That is the result of analysis of waves’ behavior before and after installation of wave power stations.

The largest proportion of material weight within Pelamis is accounted for by the main structure, which is made of mild steel, and ballast, currently in the form of washed sand. There are smaller quantities of various other metals and materials which make-up the machine and its components including: copper, stainless steel, rubber, bearings and plastics.

Unlike a vessel, where marine growth causes drag and therefore increased fuel costs, Pelamis is stationary and any increased drag due to marine growth is negligible, therefore the system is largely tolerant of growth, meaning that harmful anti-foulants are not required over the entire submerged structure.

Within the power take-off systems onboard Pelamis are volumes of hydraulic fluid, PWP uses hydraulic fluid which is biodegradable in the marine environment. In the unlikely event that a leak of hydraulic fluid occurs within the power take-off module there are two levels of egress/ingress protection on all leak points, both of which would have to fail to allow water to ingress to a point where fluid could escape to the outside environment. PWP also uses biodegradable transformer fluid.

Initial life cycle analyses that have been carried out for Pelamis, taking into consideration energy usage in manufacture of the machine and its components as well as energy usage through its operational and decommissioning phase, indicates that a Pelamis machine operating in a good wave resource (40kW/m annual average wave energy level) will have an energy payback period of less than 20 months with a life cycle emission of approximately 25g/kWhr. Under these conditions a Pelamis machine will offset the production of approximately 2,000 tonnes of CO_2 from a conventional combined cycle gas power station each year.

A marine paint coating is applied to structural steel surfaces in the atmospheric and splash zone and cathodic protection is applied to areas of the structural steel components in the submerged zone using sacrificial anodes.

Costal flora and fauna are considerably sensitive to storms, due to this conditions wave power engineering has minimal effect on the environment. 50% of Pelarmis devices remain underwater and only 2 m of the installation can stay over the water surface.

Wave Power Stations are equipped with glimmering yellow lights (flash interval of 5 seconds) in the front and in the back of the engine. These lights are seen from the distance of 2 nautical miles at nighttime.

All the mooring components of Pelamis system (chains, cables, anchors) are designed to minimize the influence on local flora and fauna species vital activity.

In case of relocation of the system to other sites, all the mooring mechanisms and anchors are extracted without big effort. During anchor system dismantling only surface sediment layers are disrupted and can be renovated in a couple of days.

Pelamis and its mooring system are capable of attracting fish schools and increase native fish population.

In the local zone of Pelarmis project, due to fish population increase, there is the growth of costal diving poultries.

Wave Power Stations are considered to be a suitable site for resting of local and migrating poultries.

Pelamis is not a large structural object therefore it does not disturb low oversurface bird flight and also cannot be seen as considerable obstacle for their diving. So, as we can see, the whole system is absolutely environmentally friendly to all aquatic species.

All the spinning mechanisms of the system are highly hermetic, they won't effect the vital activity of diving poultries. Ideally Pelarmis Converters should be stationed 5-10 km from the shore 50-60 m in depth, so that submerged cable not to be too long.

As a result, the following conclusions can be made:

- Pelarmis technology is ecologically friendly.
- The Crimea shore zone climate abides all the conditions for installation exploitation.
- Implementation of Pelamis engines will help us to solve a great range of environmental and energetic problems of the Crimea region.

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