

# Findings about the Characteristic of the Wave Power Generation in an Intense Area of the Erosion

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## 1. Introduction

Global warming has been shown using photographs, figures, charts and verified data and maybe caused by an increasing population using increased energy and oil based transport such as cars, aircraft. Evidence suggests that a major cause of global warming is the discharge of CO<sub>2</sub> into the atmosphere from the burning of fossil fuels (Gore, 2007, Houghton, 2005). These authors also suggest large scale deforestation contributes to the large amount of greenhouse gases to the atmosphere. (Parry et al, 2007) report that global warming may increase heat waves and hurricanes, affect the harvest of crops will decrease in some parts of the world and increase in others, and lead to melting of ice caps. As a result, the sea level will rise, causing coastal squeeze and the ingress of the sea, so the space available for human habitation will get smaller. ACIA (2004a), the Arctic Climate Impact Assessment suggested that if Greenland warms by 3 °C, as the climate model predicts by the end of this century, the Greenland ice sheet will keep melting in the long term and could not be stopped by human

action. As a result, the global sea level would rise 7 m. Overpeck et al (2006) also suggest that the past record of ice sheet melting indicates that the rate of future melting and related sea level rise could be faster than widely thought. Moreover, sea level rise and polar warming by 2100 may produce sea levels several metres above today's levels. This will heavily impact low lying areas such that at least 100 million persons living within one metre of sea level will have increased risk of living. Some island states and deltaic coasts are threatened by sea level rise. It is indicated that there is a correlation between coastal erosion and sea level rise and the severe coastal erosion problems in the 20<sup>th</sup> century will be exacerbated in the 21<sup>st</sup> century (Zhang et al, 2004). Hence that will be the urgent need to solve the problem of coastal erosion.

Severe coastal erosion is caused increasing in wave height due to sea level rise or high waves due to wind. In addition, coastal erosion depends on the geology of the coastal materials, wave action and tectonic forces. Tsunami, dams and thawing permafrost also accelerate to increase worldwide coastal erosion. Thus,

people who live in coastal zones and coastal area industrial facilities have to move to other places. Moreover, people threatened by coastal erosion and coastal communities face the risk and costs for moving out (ACIA, 2004b).

There are a variety of coastal defence methods being used around coasts which can be categorized into either hard or soft engineering techniques. Hard engineering techniques (groynes, sea walls, revetments, rip rap, gabions, offshore breakwaters, cliff stabilization and entrance training walls) focus on reducing wave energy by putting large structures between the sea and the land. Soft engineering techniques (beach nourishment, sand dune stabilisation and beach drainage / beach face dewatering) work with the existing natural processes rather than attempting to control them. One of the soft engineering techniques is called manage retreat or coastal realignment and it is being increasingly used. Hard engineering methods can be a useful way of controlling erosion and protecting built up coastal areas. These are normally expensive and the methods are not always environmentally friendly both visually or in terms of the maintenance of natural process. Soft engineering methods try to work with natural processes in an area and are usually based on protecting or preserving the beach. Such techniques are usually less expensive and more environmentally friendly (Nagle et al, 2008).

Previous part mentions direct countermeasures

for coastal protection. Nevertheless, there are indirect ways to affect to mitigate or reduce coastal erosion exist because coastal erosion links to increase CO<sub>2</sub>. Agenda 21 and Kyoto Protocol are world agreement to reduce CO<sub>2</sub> from the atmosphere.

At the present time, the main energy resources are coal, natural gas and oil but they are limited in supply and availability. Moreover, these fuels discharge CO<sub>2</sub>. However, renewable energy (solar, hydro, wind, geo thermal, ocean and biomass) does not pollute the air and is a clean energy source. Such renewable sources do not contribute to global warming or greenhouse effects because they are based on natural resources. One disadvantage is however that it will be very difficult to produce the quantity of electricity to apart that continually created by fossil fuels at least in the short to medium term. According to the Agenda 21 (2007), several different types of renewable energy resources are now possible, such as solar thermal, solar photovoltaic, wind, hydro, biomass, geothermal, ocean and animal. Nevertheless, although solar power is effective, it cannot create sufficient energy and is more effective in some weather conditions than others. Moreover, wind power has the same problems. If the wind does not blow, insufficient energy will be created. The sun and wind cannot create energy constantly. In addition, solar and wind power are difficult to predict accurately. However, ocean energy does not have this problem and also the

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harnessing of ocean energy has the potential to prevent coastal erosion.

## 2. Study site and methods

In this world, several countries suffer from coastal erosion which may be exacerbated by global warming. Japan is one of the countries so affected because it is a group of islands, surrounded by the ocean. The Shizuoka coast was chosen as the study site because of relevant background importance. Furthermore, the University of Tokai area and its surroundings face a coastal erosion problem because they are located close to the Shizuoka coast. Therefore some University academics, the City Council and local companies have cooperated to prevent or reduce erosion and look for another approach to deal with the Shizuoka coastal erosion.

This paper proposes a solution that links coastal erosion and energy generation. The reason why linked these maybe, is that there is a potential for both to be achieved a win-win scenario. It will mitigate or reduce erosion and create a renewable energy resource, instead of dealing with them as separate issues. Therefore, a wave power generator, especially Pelamis might be a possible solution. Moreover, it is important to identify whether a wave power generator is acceptable to operate or settle down in the Shizuoka coast or not before doing any computer modelling or laboratory model experiments because if

a wave power generator is not acceptable to the Shizuoka coast, there is no necessary to do further research. Thus the overall aim of this study is to investigate whether or not a wave power generator can operate of the Shizuoka coast in Japan for preventing or mitigating erosion and investigates the following aspects: environmental, technological, social, economic, Governance (administrative, legal) and political, by textual research. The Shizuoka coast data are taken from Shizuoka City Council records as the Shizuoka coast is administered by Shizuoka City.

## 3. Analysis and discussion

### 3-1. Environmental factors

The Shizuoka coast is located west of Suruga Bay, Shizuoka city in Japan (Figure 1). It is a shingle coast, 10 km in length (Akiyama, 2003). The Shizuoka coast area was created by sands from the Abe River, which flows from the Kunou Mountain about 14 km from the coast. The sands from the Abe River were carried by sea action and deposited to the east of the delta, building up the coastline (Akiyama, 2004). Shizuoka coastal erosion increased from the 1960s because in that period, 1200000 m<sup>3</sup> of river sand was utilised by the construction industry. There is no monitoring data available before the 1960s because Shizuoka Prefecture did not consider it until land was eroded. Moreover, the construction of dams at Kunou

Mountain caused an imbalance between sand supply and depletion, as most of the sand coming from the Abe River was blocked by the dams. As the result, the coast began to erode (Abe river committee, 2004). The reasons for building the dams were to prevent floods and improve safety for Shizuoka area citizens. However, when the dams were constructed, the builders did not sufficiently consider the effect on the environment. This is another reason for Shizuoka coastal erosion. Coastal erosion moved in an eastward direction from the Abe River to the Shizuoka coast. Figure 2 illustrates the movement of sand from Abe

River to Shizuoka coast and Figures 2a, 2b, 2c, 2d, 2e and 2f show 6 points of Figure 2 (Akiyama, 2004). The erosion rate is about 270 m/ year to the east direction (Shizuoka Prefecture Civil Engineering Department, 2006). In the 1980s the Shizuoka coast suffered serious damage from a combination of erosion and typhoon season tidal waves. When coastal erosion reached the Hagoromo pine grove, counter measures for coastal erosion began. They included the construction of a sea wall, a sand bypass scheme, the headland method and beach nourishment. In addition, Shizuoka City regulated the dredging of Abe River

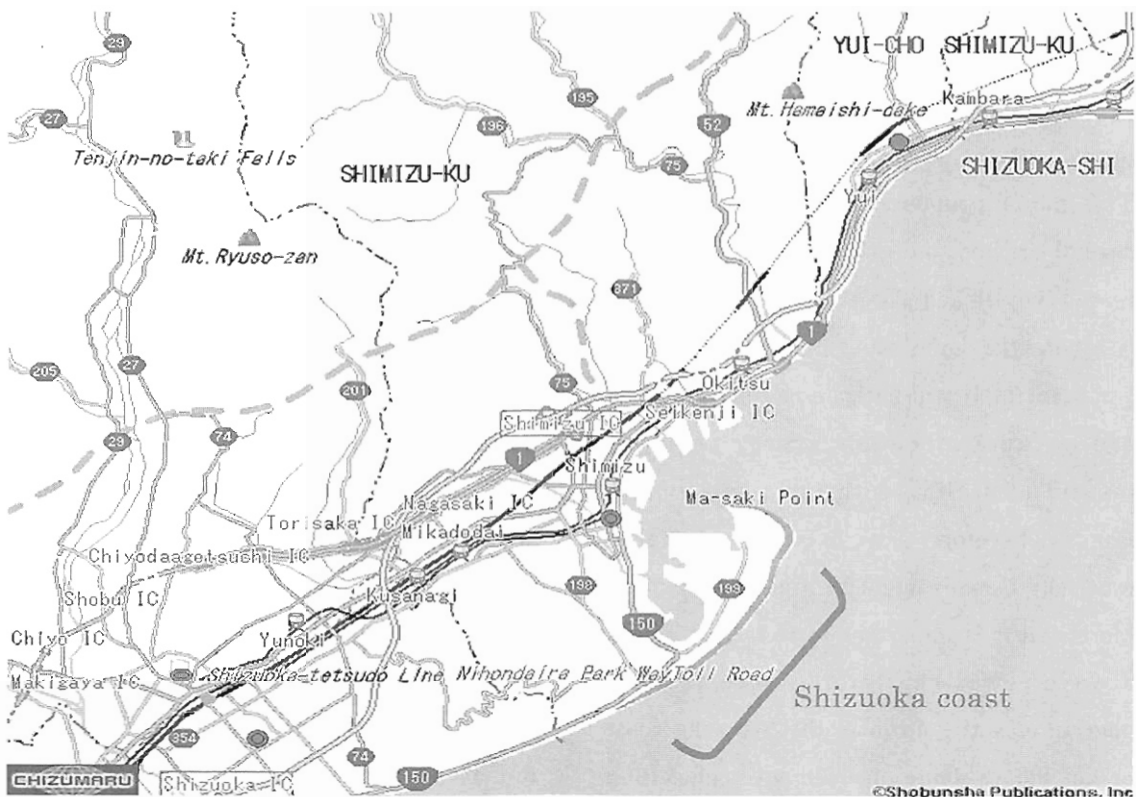


Figure 1: Map of Shizuoka coast

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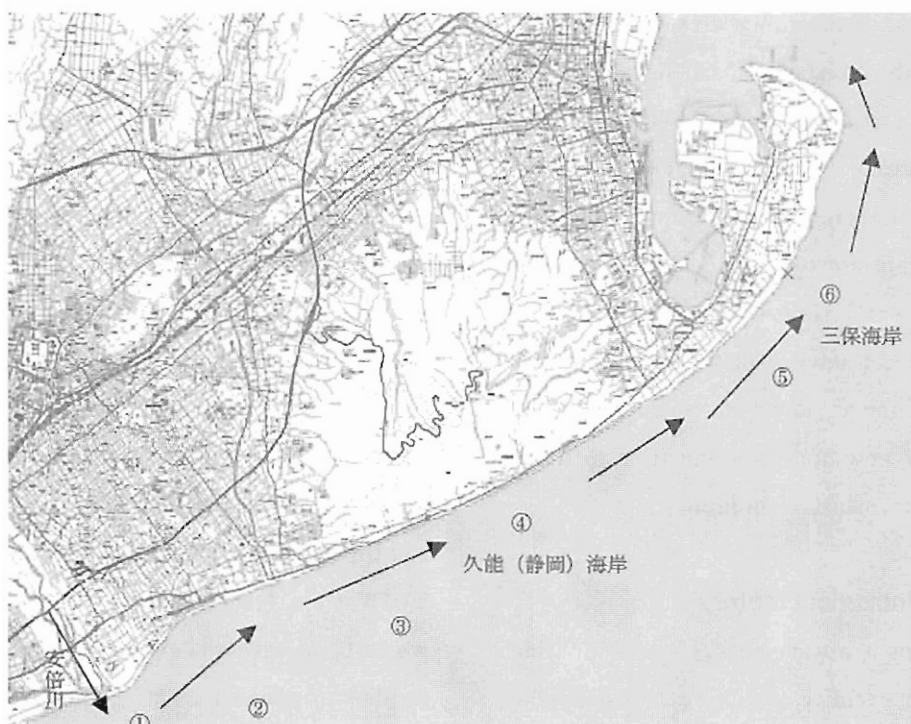


Figure 2 : Mechanism of erosion area movement



Figure 2 a: Point ①



Figure 2 b: Point ②



Figure 2 c: Point ③



Figure 2 d: Point ④



Figure 2 e: Point ⑤



Figure 2 f: Point ⑥

Legend to show the points are on Figure 2

(Figure 2 and Figure 2a - 2f are from [www.sokugikyo.or.jp/pdf/apa87\\_2004\\_09/apa8702.pdf](http://www.sokugikyo.or.jp/pdf/apa87_2004_09/apa8702.pdf))

sands. These counter measures have had some effect on the Shizuoka coast. At the current year, the coast has experienced a gradual recovery from erosion (Shizuoka Prefecture Civil Engineering Department, 2006). The most appropriate technique for the Shizuoka coast currently time is that combination of 5 headlands, 1 jetty, 4 offshore break waters and nourishment. However, Shizuoka coast is looking for new approach and tries to reduce these countermeasures in future.

### 3-2. Technological factors

The Pelamis is a wave energy converter which creates electricity by using ocean surface waves and is made by Ocean Power Delivery Limited (OPD) (Henderson, 2006). The company is based in Edinburgh in Scotland and started to develop the concept of Pelamis in 1998 (Power Technology, 2007). It is a semi-submerged wave energy converter which links by hinged joints. The wave movement makes the joint part move and pumps high pressure oil through hydraulic motors. The motors run electrical generators to produce electricity. The Pelamis has a mooring system and all the electric power goes through the single cable which links Pelamis and the shore. As Figure 3 shows, the full scale prototype dimensions are 150 m long and 3 m diameter containing 3 power conversion modules. The overall weight is 750 tons. Each modules rate is 250 MW and each has an electro hydraulic power generation system. Pelamis is

most efficient when moored in water 50 to 60 m in depth and 5 to 10 km from the shore (OPD 'The Pelamis wave energy converter' , n.d.).

OPD tested the first full scale prototype of Pelamis at the European Marine Energy Centre in Orkney, Scotland. The Scottish Government has announced in 2007 that the Pelamis farm project has more than 4 million pounds sterling in funding. This project will be located at EMEC in Orkney with 4 Pelamis devices. These machines will be expected to produce 3MW and the future wave farm project could produce 30MW from 1 square km of the ocean. This would be in excess of the amount of electricity needed to support 20000 homes (OPD 'UK' s first wave farm project announced' , n.d.). Pelamis full scale production programme was commenced by Enersis and OPD in May 2005. Due to the first commercial contract for Pelamis being agreed with Enersis, OPD developed a wave farm 5 km off the northern Portuguese coast, near to Póvoa de Varzim. This project is expected to eventually have a 2.25 MW capacity and it could supply the electricity demands of more than 1500 Portuguese households (OPD 'Production of the P1A machines' , n.d.). In 2007, this first commercial wave farm was settled off the coast of Portugal with three Pelamis devices (Plunkett, 2007). To enable successful operation OPD will need to reduce the total cost of the Pelamis system, perhaps by offsetting against other commercial ventures. Other areas of necessary development are: the

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optimization of the device's configuration; the development of its structure and the system for volume production; and further enhancement to maximize the energy captured (OPD 'The future', n.d.). Other concerns are the reduction of maintenance costs, environmental impact assessment, the verification of a viable lifespan and assurance that Pelamis can operate reliably enough under harsh sea conditions over 25 years (NEDO, 2007). When the Portuguese wave farm project is completed, it should displace over 60000 ton per year of carbon dioxide emissions (Power Technology, 2007). Pelamis is the best option of the wave power generators because of low risk (Douglas et al. 2005) and energy supply efficiency at the present time.

### 3-3. Socio-economic factors

#### 3-3-1. Social factor

Shizuoka city has a vision for the future. It coexists with the sea, its people and the demands of a modern city, is becoming an international marine culture centre because it city is surrounded by sea and mountains. It is using the natural environment for its identity. Moreover, Shizuoka society tries to be an international and attractive cultural city at same time because of attractive people. The ports are a prime factor in establishing Shizuoka's profile in the national consciousness (Shimizu city public relations section, 1998). Shizuoka social background has close relationship with sea and Pelamis is creates energy from the sea thus Pelamis project might be helpful for Shizuoka to be international and attractive

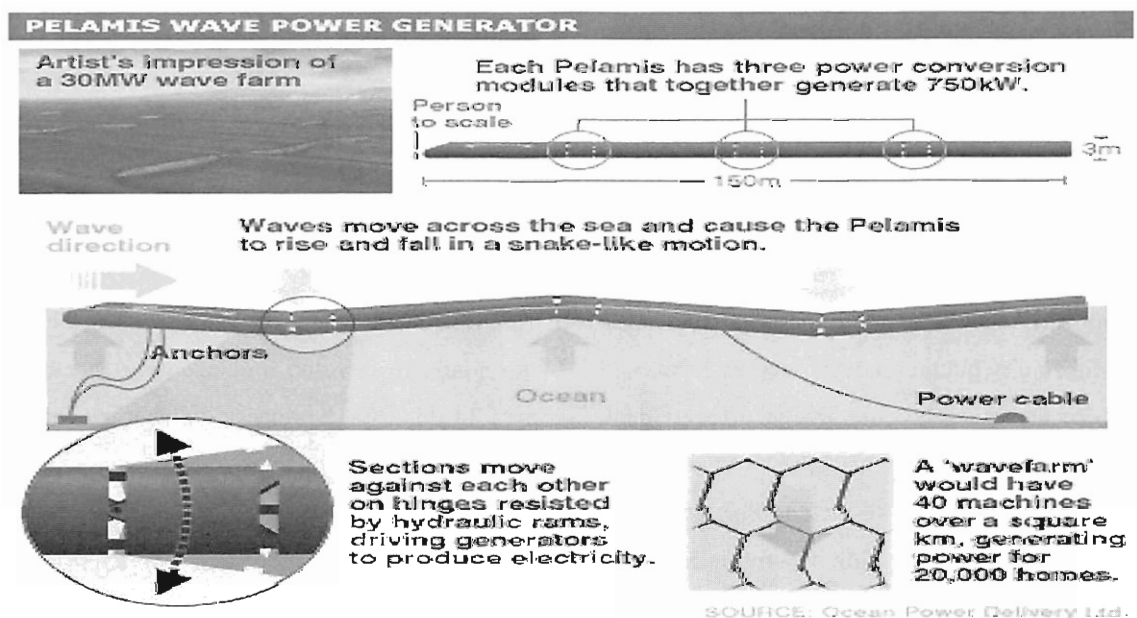


Figure 3: Pelamis wave power generator ([http://news.bbc.co.uk/2/hi/uk\\_news/scotland/6377423.stm](http://news.bbc.co.uk/2/hi/uk_news/scotland/6377423.stm))

marine cultural city.

In 1989 the Shizuoka port celebrated its 90th anniversary and was visited by Queen Elizabeth II in February the following year. Shizuoka society is developing future frameworks to become an international marine cultural city. These plans include building an artificial island in the offshore Shizuoka port area and also constructing a marine biotechnology research centre. These are because of regenerate Shizuoka area. The artificial island plan is that 240 ha space will be claimed to be used for a variety of purposes or activities. Aspects of these include creating a distribution centre and developing intelligence gathering facilities, besides encouraging the creation of educational and recreational opportunities. The impact on coastal erosion needs to be considering. The aim is to construct whole plan for future development and consolidate the city's links with the sea. Biological research has gained public attention in recent years and Shizuoka's location obviously lends to itself to the development of business opportunities in the fields of ocean or marine technology research. This will impact favourably on local companies (Shimizu city public relations section, 1990).

There are many events which attract local and national support through the year in the Shizuoka society. These include Shizuoka Port Festival, Hagoromo Noh Festival, Shimizu Nihondaira Marathon Race, All Japan Boy's Football Championship and Nihondaira Summer

Festival. The port area offers a variety of diversions for sightseeing. For example, the large aquarium allows visitors to encounter a huge number of marine creatures in a constructed 'natural' environment. There are also sightseeing trips by boat which also run at night (Shimizu city public relations section, 1996).

Shizuoka's endeavours to utilise its coastal location include plans to develop cultural activities which have a maritime element. Major developments to provide an infrastructure for these ventures are planned. These include the second Tomei motorway construction project which will provide 4.5 km of connection roads, two interchanges and a parking area. A motorway link between Shizuoka and Saku cities was designed and agreed in 1987. This 150 km central area crossing is progressing gradually and will facilitate access to the planned hot spring resort in Shizuoka (Shimizu city public relations section, 1998). Shizuoka construction developments may be helpful to attract the Pelamis project to invite the Shizuoka are.

As explained in above section, Shizuoka already has plans to develop and promote the local area. In this case, a co-operative venture with a renewable energy business would have shared advantages. The resulting public interest from an innovative renewable energy project would help to create the city's new image and gain positive publicity for the area. One of the



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negative results of Japan's problem of an aging population is that young people are leaving their rural and less developed native areas to congregate in the capital and larger cities. However, if Pelamis or another renewable energy business were to become established in Shizuoka, this could create a significant impact on urban redevelopment. Young people who have left the area may be encouraged to return and there would also be an influx of population from other areas. From the perspective of Shizuoka society the Pelamis partnership would be an extremely positive collaboration which would create excellent opportunities for the future. Similarly, the expansion plans already in place in Shizuoka would provide important advantages for Pelamis.

In addition, as explained before, Shizuoka city has a number of activities and events through the year which relate to the sea. If a renewable (Pelamis) project or company come to the Shizuoka, it would add an extra activity and benefit the regeneration of the Shizuoka area. There is even the possibility the renewable business site (Pelamis) would become one of the main sightseeing location. Furthermore, if Palamis has a mascot character, it will be able to create a side business or get attention from the mass media and regenerate Shizuoka area. Wind velocity of around Shizuoka coast is approximately 10m/s from North and South West direction (Shizuoka Prefecture, 1995). Wave height is about 0.95 to 0.65 m. When

surge comes, significant wave becomes about 5.3 m. The wave come North East to South West direction (Shizuoka Prefecture Civil Engineering Department, 2006). Therefore, Shizuoka coast area has possibility to suitable wave climate for Pelamis.

### 3-3-2. Economic factor

Shizuoka prefecture has a 3 % share of the Japanese economy and was ranked 10th out of 47 prefectures in 1993. It also had become an industrial prefecture during the past 3 decades. The next tasks to develop the economy are those of making high additional value and training in the area of high technology, i.e. Shizuoka's economy needs to shift to an advanced level (Shizuoka Economic Institute, 1993).

Shizuoka Economic Institute (1993) reported a growth rate of the Shizuoka population at this time of 33.2 % (See Table 1) which exceeded 2.1 % of whole country's growth rate. This increase proved that Shizuoka's economy was developing smoothly.

The Shizuoka prefecture has a 647 km coastline, several harbours and a good fishing area; so as expected Shizuoka's fishery industry is reknowned. Shizuoka port is ranked in fourth place in the national figures for total fish catch and earning about 24 million pounds sterling. Fishery plays a strong part in assisting Shizuoka's economy (Shizuoka Economic Institute, 1993). Moreover, Shizuoka is

developing high speed traffic network projects to promote the prefecture's economy. These cover land, sea and air transportation projects, as Shizuoka is negotiating to construct its own air port and second Tomei highway projects. In addition, Shizuoka has 65 harbours so the Ministry of Transport has developed high speed passenger and cargo boat networks. These massive land, sea and air projects improve access between Shizuoka and the capital which includes time factors involved in raw materials, finished product and personnel transport. This benefits the companies' economic growth but also benefits the local community. The economic ripple effect for Shizuoka is immeasurable

(Shizuoka Economic Institute, 1993).

The capital over-centralization has not significantly affected Shizuoka's Prefecture as young people usually move to big city thus the capital has huge population and retired or older people stay in the local area thus the local area has less population. The Tokyo over-centralization has remarkably increased so Shizuoka has to consider that how it can contribute to Japanese development and how Shizuoka can serve its inhabitants. The key points are that Shizuoka has to be economically independent from the capital and other areas and become a foothold prefecture for globalization and worldwide economic

Table 1: Population change of Shizuoka prefecture and the whole country (Shizuoka economic institute, 1993), Population of Shizuoka 1995-2005 data are from Shizuoka Prefecture (2009) and Population of whole country 1995-2005 data is from Japanese Ministry of Internal Affairs and Communications (2008)

Year	Population of Shizuoka		Population of whole country	
	(Population)	growth rate		growth rate
1960	2,756,271	4.0	94,301,623	4.7
1965	2,912,521	5.7	99,209,137	5.2
1970	3,089,895	6.1	104,665,171	5.5
1975	3,308,799	7.1	111,939,643	7.0
1980	3,446,804	4.2	117,060,396	4.6
1985	3,574,692	3.7	121,048,923	3.4
1990	3,670,840	2.7	123,611,167	2.1
1995	3,737,689	1.8	125,570,000	1.6
2000	3,767,393	0.8	126,926,000	1.1
2005	3,792,377	0.7	127,768,000	0.7
	2005 / 1960	37.6	2005 / 1960	35.5

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activities. Shizuoka has the potential to lead Japan (Shizuoka Economic Institute, 1993). In 1980 the Japanese government established an organization for the development of New Energy and Industry Technologies which calls NEDO. Shizuoka is involved in the third sector of this venture and has a research centre for the 'industrial utilization of marine organisms'. This research centre has advanced facilities and is involved in government projects with the Marine Biological Institute. The research centre and institute cooperate with local Shizuoka companies to provide knowledge and advice, thereby also directly supporting the local economy. The main agricultural contribution to Shizuoka's economy is the mandarin orange, green tea and strawberry crops (See Table 2) (Shimizu city assembly secretariat, 2002).

As previous section explains Shizuoka's strong economic fields are sightseeing, fishery, green tea, strawberry, and mandarin orange production. Moreover, Shizuoka has a good infrastructure of land, sea and air transportation systems. If a renewable energy company was established in Shizuoka, it would benefit

the area because there is the opportunity to contribute to the development of this huge project. Other business opportunities would arise as a result of this such as in the areas of international language studies and translation services, service industries, real estate, food production and sales and hospitality industries. To expand upon this, because Pelamis originated in the U.K. All technical data and expertise is available in English, rather than Japanese. At the present time, Pelamis might have potentially efficient solution for Shizuoka coast. Therefore the opportunity for language and development services to be embedded within this project. The English technicians who would be necessary to set up such a project need Japanese language services, including tuition and translation. The local Japanese staff who would be recruited need to understand English of a technical nature and would therefore need dedicated language courses. Spin offs also include the establishment of retail outlets catering to foreign national needs and tastes. As is evident from the non-nature, communities in Tokyo, Yokohama

Table 2. The outline of the main crop (Shimizu City Assembly Secretariat, 2002)

	Production	Production price
Mandarin orange	19,000 tons	227 ten million
Green tea	12,550 tons	290 ten million
Strawberry	938 tons	86 ten million
Rose	1 1000 thousand	59 ten million
Tomato	1500 tons	41 ten million

and other centres of European settlement, international supermarkets newspapers and journals, hairdressers, restaurants, book shops and cafes are quickly established. If Pelamis were to be successful in Shizuoka, this would generate both primary and secondary employment opportunities in the area. Apart from this tangible result, however there would also be wider worldwide ideological implications as Pelamis would set a positive example for renewable energy generation for the future. Furthermore, 103,308 foreigners (Brazilian: 49.9 % , Chinese: 13.3 % , Philippine: 12.2 % , Peruvian: 6.4 % , Korean: 6.2 % , Indonesian: 2.5% , Vietnamese: 2.0% , Thai: 1.1% , American: 0.8 % , Argentine: 0.4 % ) stayed in Shizuoka Prefecture in year 2008 (Shizuoka Prefecture, 2008) thus Shizuoka area is already used to working with foreigners and foreign companies. Shizuoka would be best place to smoothly settle down business for the foreign companies. In addition, Shizuoka Prefecture has almost 4 million populations in 2009 (Shizuoka Prefecture, 2009) which means the Prefecture needs to provide a huge amount of electricity to the citizen. Economical point of view, there could be opportunity that renewable project or companies might be enter or join into the Shizuoka domestic market however, there is consideration to be conflict with local energy supply companies because renewable energy companies or projects would take their share from the market.

### **3-4. Governance (administrative, legal) and politics factors**

#### **3-4-1. Governance (administrative, legal) factor**

In 1870, both France and Germany were at war with each other and both countries' warships stayed near Japan. Japan did not have any law of the sea at that time so there was a possibility that the war would spread to Japan. Because of this threat, the Japanese government decided to make a law of the sea to protect Japanese territorial seas and prohibited Japanese waters to be utilised for naval engagements by any country against any country. This was the beginning of Japanese law of the sea (Mizukami, 2005). Japan joined the international convention on the Law of the Sea in 1984 and the Japanese territorial sea became 12 nautical sea miles (22.224 km) (Mizukami, 1995).

Article 245 of Convention on the Law of Sea shows that coastal countries have exclusive jurisdiction and control right about scientific research and investigation in the territorial waters therefore 'the agreement of clear statement' of the coastal country is necessary for any kind of activity and also if the coastal country demands, it must follow that condition. Moreover, the initial terms of Article 56 of the Convention on the Law of Sea says that the coastal country possesses sovereign right for the investigation of the natural resources, development, prevention and management in the area between the water surface and

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the seabed. In addition, sovereign right about investigations performed for economical purpose in the exclusive economical zone and activity for producing energy from the sea water, the ocean current and wind is allowed in a coastal country (Mizukami, 2005).

Furthermore, Chapter 2 Article 5 of the Japanese seacoast law also says that the Prefecture governor integrates the coastal area and manages coastal protection districts (Law of Japanese seacoast, 2007).

As previous section explains, a renewable energy company will require permission from the Shizuoka Prefecture governor to operate a wave power generator on the Shizuoka coast. However, it is necessary to consider several laws which relate to the law of sea and coast. These are about marine pollution and compensation for damages because if a wave power generator has any accident due to a strong storm or fuel (oil) spillage flows, how and by who will compensation be initiated and through what legal action? Moreover, Pelamis is a moored type generator and if a chain or mooring is broken by a large scale typhoon and it causes damage to the sea coast, what kind of laws can be employed. These areas of the registration require further research.

The Basic Act on Ocean Policy was enacted year 2007 in Japan. It aims at comprehensively developing and utilising the jurisdictional sea zones of Japan (the territorial sea, continental shelf, exclusive economic zone etc). This Act

consists of four chapters. The first chapter is 'General Provisions', providing the purpose and principles of this Act. The second is 'Basic Plan on Ocean Policy' providing that the government draws up basic plan relevant to the sea zones pursuant to the purpose and principles in the first chapter. The third is 'Basic Measures' providing the essentials to be reflected in Basic Plan on Ocean Policy. The last is 'the Headquarters for Ocean Policy' which promotes measures relevant to the sea zones intensively and synthetically (Japanese Ministry of Land, Infrastructure, Transport and Tourism, 2007).

The behind reason the enactment the Basic Act on Ocean Policy, is the competition for the exploitation of natural gas reserves between Japan and China. In 2005, natural gas was found around middle line of exclusive economic zone between the above two countries. Japan is a marine nation however the maintenance of the law of sea is not good enough or too late. This is because Japan has many ministries and government offices related to the sea and a lot of related regulatory controls exist along with it thus it was very difficult to deal with to perform the adjustment (Ushio, 2008). Nevertheless, the development of legal systems concerning ocean power energy is being straightened thus there new laws would be supportive to settle down renewable project or companies in the Shizuoka area.

### 3-4-2. Politics factor

The University of Tokai is located in Shizuoka city and this University is trying to create electric energy from Biomass. This Biomass means wood and ligneous Biomass generation and that energy turns to gas then the gas energy is used for electricity. This wood and ligneous Biomass generation project has cooperation and support from Shizuoka local wood companies to get woods for Biomass fuel generation. The project leader is Tokai University professor Hiromichi Tanaka who has a plan to create electric energy from renewable sources, especially using a Biomass generator in order to provide all the University's electricity. Furthermore, when this Biomass project is developed, the project leader has designs to produce electric energy for the Shizuoka city. Therefore, Shizuoka citizens will not need to pay electricity bills in the future because electricity bills will be covered by renewable energy so in order to achieve this project, local Shizuoka companies and Shizuoka city cooperate and support this Biomass project. Shizuoka's politicians are also cooperative to this project because if this project is successful, it will get attention from other cities and politicians. Moreover, this project is in accordance with government policy. As a result, Shizuoka politicians are also supportive towards renewable projects or companies coming to the city. If renewable energy projects are pushed forward to development and cover all Shizuoka

city's electricity needs, Japan will become the leading country for renewable energy. This is the direction where technological development in Japan should be focussed.

New Energy and Industrial Technology Development Organization (NEDO) was established by the Japanese government in 1980 to research and develop renewable energy technologies. In 1981, Shizuoka city developed a marine research centre. It was the third sector of NEDO (Shimizu city assembly secretariat, 2002). From that time, Shizuoka city mayor and Shizuoka politicians considered having new oil alternative energy technologies. Mr. Heita Kawakatsu was inaugurated as top of the Shizuoka Prefectural governor in 2009 (Shizuoka Prefecture assembly, 2009). Kawakatsu has published several books which relate to the sea and Shizuoka Prefecture has renewable energy projects, promotion activities, academic seminar and try to use it into the Prefectural facilities. Head of the Shizuoka Prefecture is already cooperative to use renewable energy (Shizuoka Prefecture, 2003) therefore Shizuoka is best place to do renewable business or projects.

If Pelamis and the renewable energy company come to Shizuoka city and establish a base there, politicians will be encouraged to follow the renewable energy route, with associated potential for global warming benefits. Japanese politicians need to take a world lead and attempt to influence politicians all over the world, following the example made by Al Gore

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(2007).

Sakota (2005) provides a vision of the future for a renewable city where there are young people returning to their home city because renewable energy companies are there to provide work. Whereas in the past, many cities were made up of only an elderly population because of lack of employment opportunities, young people will be able to get jobs in their home city. Amenities will be built and provided so that young people will be tempted to start families. Moreover, people will visit the city from all over the world to inspect the facilities. Japan should pioneer the application of practical renewable technology as a world model because most countries are going to face environmental problems in the future and a solution is required. In addition, infrastructure is important and necessary for this. Universities, government, companies and research organization will be required to cooperate to develop renewable technology and systems thus once Pelamis comes to Shizuoka, more local politicians would join to approve for renewable energy projects and business then it could affect to other area's Japanese politicians.

### 4. Conclusion

This study investigates whether or not as a wave power generator can accept to operate at Shizuoka coast in Japan. It used seven aspects such as environmental, technological, social, economical, administrative, law and political

by texture research. The reason why seven aspects were looked at in this research is that coastal erosion links a wide area of issues thus this research needed to consider more than one aspect. The conclusions give a following.

**Environmental Factor:** Coastal erosion is a big problem in Japan. This is a world problem mainly because of global warming. At the moment there is the CO<sub>2</sub> trading system. However, wave power is one of the renewable energy resources and it has potential energy for producing electricity. Environmental consequences of Pelamis are acceptable to the Shizuoka coast because it has low impact to the marine mammals, fish and scenery.

**Technological Factor:** Japan is surrounded by the sea and suffers from serious coastal erosion. The Shizuoka coast has several countermeasures for protection or mitigation to the erosion however these do not work well thus Shizuoka City is looking for a new approach to mitigate coastal erosion. The wave power generator, especially Pelamis would be the best solution for Shizuoka coast because this is the latest version and it produces electricity effectively at the present level. Moreover, it is half submarine so big waves and tsunami can go through or above the Pelamis. This is to reduce the risk and mitigate the potential an accident from a natural disaster.

Man has tried to use wave energy over the past few centuries. The United Kingdom has many wave power generator patents and also has

latest wave power generator. This means, the United Kingdom has advanced technology and information for the wave power generator. The next targets are: reducing the total cost of wave power generator systems, the optimization of the device's configuration, the development of its structure and the system for volume production, further enhancement to maximize the energy captured. Other concerns are the reduction of maintenance costs, environmental impact assessment, the verification of a viable lifespan and assurance the wave power generator can operate reliably enough under harsh sea condition over 25 years.

Japan has some wave power generators but these are still in development. Japan is rich wave energy country because it is surrounded by sea and it has potentially 36000000 kW of wave energy to be harnessed. In this thesis, it is difficult to estimate how much Pelamis can take out energy from Japanese coasts. This is required to do further research and identify the energy captured.

**Social Factor:** Shizuoka City has many business opportunities for renewable projects because Shizuoka City has a 647 km coastline, several harbours, ports and a good fishing area. There is a large event plaza and also shopping malls near the Shizuoka coast. Shizuoka Prefecture plans to be international marine cultural city.

**Economical Factor:** The Japanese economy has recently recovered from a period of debt and deflation which has taken almost 15 years to

overcome. Japan tries to shift to use renewable energy because of global agreement to reduce CO<sub>2</sub> from the earth.

**Administrative and Law Factor:** The Law of Japanese sea coast says that the Prefecture governor integrates the coastal area and manages coastal protection districts thus permission from Shizuoka Prefecture governor is necessary for the wave generator to operate on the Shizuoka coast. At the same time, there are problems concerning the laws regarding marine pollution and compensation for accident by strong storm and fuel (oil) flows, environment would cause serious damage. These area laws need further research.

**Political Factor:** The Japanese government has taken the Biomass integrated strategy action plan since 2002. The Japanese Prime Ministers follow the projects for environmental issue so Biomass projects are kept developing. Shizuoka politicians are also supportive towards renewable projects and companies coming into the city. Politicians could make their views on the environmental issues important for campaigning.

An innovatory aspect of this research is that it has two areas of consideration:

the wave power generator is usually considered only for that facility but on other valuable aspect is coastal protection. Most people do not know that full potential and importance of renewable energy effectiveness.

Overall, this study has achieved its objectives



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and with the limited review of the literature available, shows that it is possible to operate a renewable energy converter in the Shizuoka coast. As a result of this study the following concluding point can be made:

A wave power generator can accept to operate in the Shizuoka coastal area in Japan for the prevention or mitigation of erosion.

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## ABSTRACT

### Findings about the Characteristic of the Wave Power Generation in an Intense Area of the Erosion

Hideaki TOYOSHIMA

Global warming is happening because of human activities and the over accelerated consumption of fossil fuels. As a result, sea level is increasing every year and coastal erosion is a serious problem almost all over the world. Japan is one of the countries suffering from coastal erosion because Japan is surrounded by the sea and the Shizuoka coast in particular faces severe, extensive coastal erosion problems.

The world needs alternative energy resources and also coastal protection to address sea level rising. These are urgent tasks. The renewable energy converter Pelamis has possibilities to address some of these problems. Therefore this study aim is to investigate whether it can accept to generate in the Shizuoka coast for preventing/mitigating erosion or not. The research has used seven aspects to determine the project aims. These are environmental, social, technological, economic, administrative, legal and political aspects.

## 浸食の激しい地域におけるウェーブパワージェネレーションの 特性に関する調査結果

豊 島 英 明

地球温暖化は、人間が行う様々な活動や化石燃料の大量消費により起こっている。その結果、海面が毎年上昇し、海岸浸食は世界中で深刻な問題となっている。日本は国土を海に囲まれているため、海岸浸食の被害を受けている国々の一つである。特に静岡海岸は広範囲かつ深刻な海岸浸食問題に面している。

世界の国々では、化石燃料に代わるエネルギー資源と海面上昇の影響による海岸地域の保護・保全が求められている。これらは緊急の課題である。自然エネルギーを利用する波力発電機（ペラミス）は、それらの問題を解決できる可能性がある。その為、本研究は、波力発電機（ペラミス）が静岡海岸浸食防止、又は軽減の為に導入可能かどうかを調査することを目的としている。そこで、本研究では7つ（環境、社会、技術、経済、行政、法律、政治）の観点から調査を行った。