Nyheim

The Offshore Floating Shelter

Give Me Five

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Team Composition

We are a diverse team of six members with different backgrounds. The competences are described as following:

Ning - Market Analyst focuses on market applicability.

Lichao - HSE Engineer deals with safety and environment issues.

Kun - Marine Engineer is in charge of structural design of product.

Juntao - Mechanical Engineer denotes industrial design and evaluation of the performance.

Fenfen - Maintenance Engineer plans maintenance activities and carries out life cycle cost analysis of product.

Can - Mechanical Engineer designs structure inside product.

1. Summary

A self-powered, self-fed and self-ventilated offshore floating shelter is designed to ensure survival of the patients, elders and children in extreme weather.

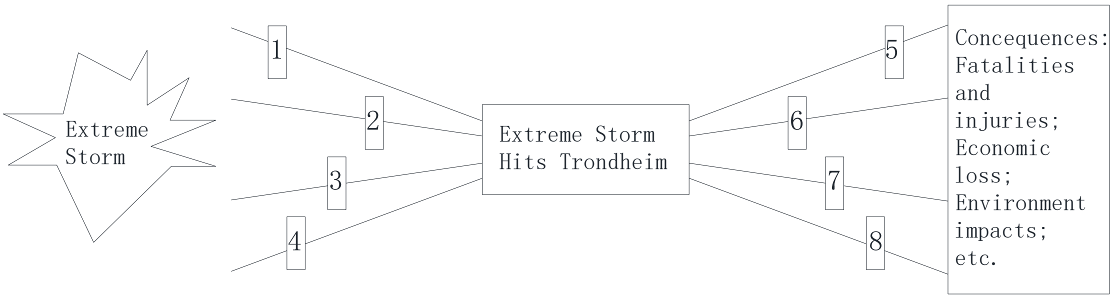
2. Scope of Project

It assumes that Trondheim has suffered from extreme weather on 7 October 2050. Under such circumstance, the whole city will face dangers such as being flooded, loss of power supply, loss of transportation and communication. The residents may lose their homes and their families even their own lives. The hospitals will eventually stop functioning after backup generators reach their limits. The lives of patients may hang in the balance. In order to sustain treatments for the patients, our group believes that the patients should be transferred to a safe place before the extreme weather attacks Trondheim, so as the aged people and children. This place shall be equipped with enough fresh water, food and all desired medical equipment with sufficient power supply.

3. Risk Analysis

Due to tendencies of global climate change, many extreme weather events in recent years have been widely discussed. There could be the dramatic consequence in the future if there are lacks of preparations.

Considering the problem stated in this project and historical disasters in other countries, such as super storm "Sandy" of USA in 2012 and typhoon Haiyan of Philippines in 2013, the risk analysis using Bow-Tie model has been performed and demonstrated in Figure 1.



Barriers:

1 – Weather forecasting; 2 – Emergency evacuate plan; 3 – Effective draining system; 4 – other preventive barriers;

5 – Emergency power supply; 6 – Resource storage; 7 – Rescue; 8 – Communication guarantee.

Figure 1 Bow-tie Model

It has been recognized that failure and deficiency of identified barriers (both preventive and active) would lead to the death and injuries, environment impact and possession loss. Therefore, the barrier functions will be the basis of the design solution. In this case, human lives occupy the priority. Since patients, elders and children are more vulnerable in storm; we propose the model as an emergent shelter that provides safe place, medical treatment, enough food and abundant power.

4. "Nyheim"

4.1 Required Functions

In order to fulfill the expectation of providing accommodations and medical treatment in the storm, there are many technical challenges that should be figured out in terms of structure construction and intellectual technology. A function breakdown has been performed to extensively analyze the function requirements to design Nyheim.

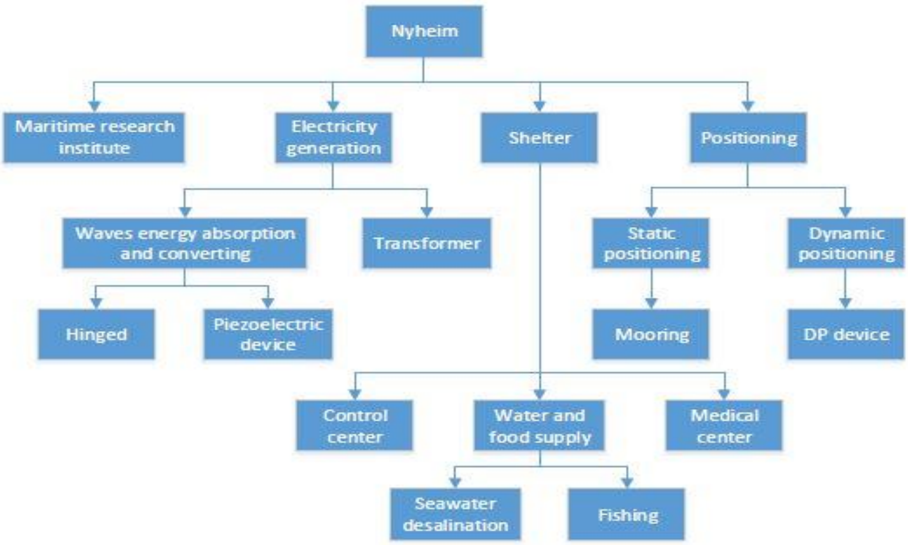


Figure 2 Function Breakdown

4.2 Pelamis- Inspiration

The fundamental technology of "Nyheim" is based on the wave energy converter "Pelamis", which is developed by an Edinburgh-based company- Pelamis Wave Power. The Pelamis wave energy converter (WEC) is a floating offshore device that could convert wave energy into electricity to send ashore by using standard subsea cables and equipment. It is a semi-submerged, articulated carbon-steel structure which composes of five multiple cylindrical sections linked by hinged joints. Waves bend the semi-submerged tubes at these joints, which house hydraulic cylinders to resist the motion and in return to pump fluid into pressurized accumulators to generate electricity. Three mooring lines are used to keep the Pelamis in position. Control system of this pumping action enables the conversion to be maximized when waves are relatively small and the outcome to be minimized in storms. The detailed design of Pelamis is illustrated in Figure 3.

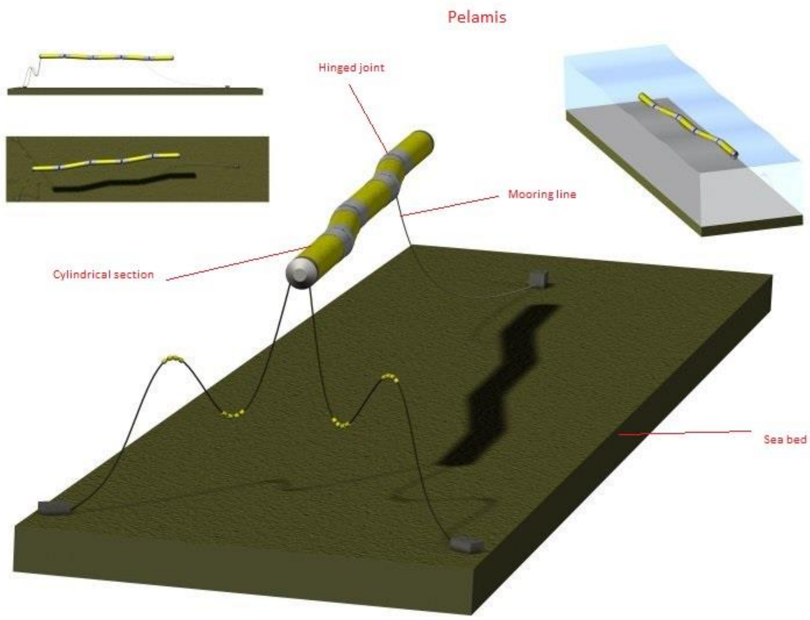


Figure 3 Structure of Pelamis

4.3 Nyheim- Integrated Solution

Referred to the Figure 2- Function Breakdown, there are more required functions compared with Pelamis. Some developments and modifications of the structure are illustrated below to fulfill new commands as a solution for emergent situation.

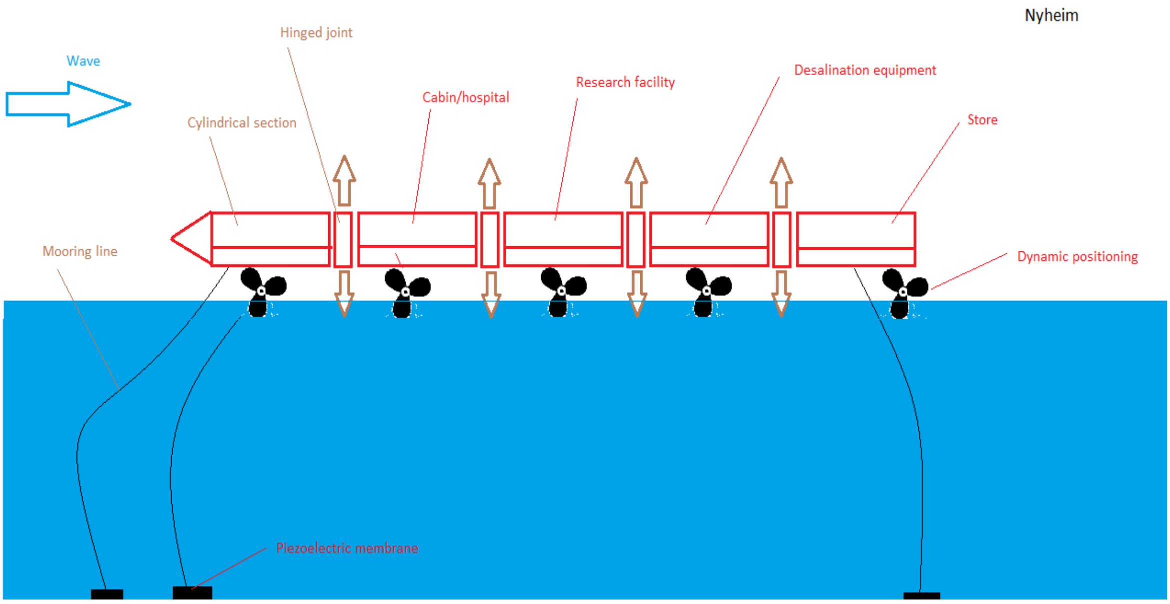


Figure 4 Structure of Nyheim

1. The Nyheim is comprised of five multiple cylindrical sections linked by hinged joints with sleek and streamlined form to minimize the friction between the Nyheim and the water in order to increase the lifetime of the Nyheim.

2. The utilization of small frontal cross section cooperated with the drag force from the mooring lines and hinged joints between cylindrical sections enable Nyheim to dive in the wave crest to survive when facing large wave in harsh environment.

3. The length and diameter of Nyheim is scaled to 200m and 5m and it is facilitated by ventilation systems. This makes it possible to be utilized as living quarters and provide space for good equipped emergent hospital and even accommodations when it is needed in case of storm. The increase of displacement is an extraneous profit after the dilatation of the structure, which could enlarge the load carrying capacity of Nyheim.

4. The usage of essential medical equipment, food and water as ballast instead of sand is of high benefit during the storm when they are needed.

5. The installation of the measuring and recording facilities endows Nyheim function of Maritime Research Institution.

6. The adjustable mooring lines and wave-curvature energy generating mechanism ensure the availability of Nyheim even though the sea level is increased due to the storm,

7. The full power of Dynamic Positioning (DP) control system to minimize the vibration of Nyheim guarantees the comfort to work and live inside during storm. Meanwhile, DP system functions as a supplementary positioning method during normal operation.

8. The simplicity and similarity of the construction and installation make it possible to produce several Nyheims to form a grid with multi functions, e.g. hospital, accommodations etc.

9. A semi-permeable membrane for seawater desalination is utilized in Nyheim to produce fresh water for the personnel in Nyheim.

10. One new device uses piezoelectric polymers membrane to convert mechanical energy from fluid flow into electricity, which locates at the bottom of mooring, and transfer the electricity to destination by umbilical to power small sensors for maritime research and generate bright colored lures to attract fish.

5. Functions of Nyheim

After establishing the structure of Nyheim and exploring the support intellectual technology, the aim of this chapter is to classify the practical functions of such innovative design. The main functions here are market applicability in both short and long term. Nyheim has essentially three prominent main functions, which are Multifunctional Emergency Center, Wave Energy Converter and Maritime Research Institute.

5.1 Multifunctional Emergency Center

In accordance with the Bow-tie model, the concept of emergency center is derived from reactive barriers of risk analysis model, which shows the consideration of reactive solution to the occurrence of storm. The main purpose of Nyheim is to function as a shelter that provides accommodations, emergency service and health service during and after the storm. Furthermore, it is always troublesome to supply food and drink during the natural disaster. In order to solve the problem, Nyheim is facilitated with the systems of seawater desalination and food storage room. It means a "self-sufficient society". In addition, Nyheim can also be used to as a temporary offshore hospital if there is a major marine accident nearby.

5.2 Wave Energy Converter

Besides the food and water supply, electricity support is obvious an issue during accident. The advantage of self-converter power supply to emergency service is its advantage especially during the storm. Based on the fact that Nyheim functions as a wave energy converter in normal operation, it is good represent of Green Energy with long-term economic benefit.

5.3 Maritime Research Institute

It is a fact that most severe natural disasters (i.e. storm, tornado, etc.) are impossible to be avoided. However, there should be a way to mitigate the level of consequence of them on the human life, assets and environment according to the preventive barrier shown in Bow-tie model. Therefore, accurate weather forecast and warning system are definitely indispensable. One meaningful function of Nyheim before the storm is designated as a maritime research center with the purpose of collecting metocean data to support construction of offshore structures and forecasting severe weather to better protect Trondheim and Sør-Trøndelag County.

6. Life Cycle Cost

Tabel 1 Cost and Benefit Classification

Cost	**Description**
Installation	The cost of the design, installation and debugging of the Pelamis.
Operation	The cost of keeping the whole system in order during the daily operation.
Maintenance	The cost of preventive and corrective maintenance.
Benefit	
Electricity	Each machine can supply power for 500 homes' annual consumption.
Research achievements	Firsthand Metocean data; Forecast extreme weather
New technology exploration	New energy development: ocean waves energy; Seawater desalination technique;
Storm economic loss reduction	Before the storm: investigate the early warnings of storms via ocean current analysis and inform the government to prepare in advance; After the storm: provide a shelter for citizens to reduce fatalities and injuries

A simplified life cycle cost model:

C_I - The total installation cost, paid immediately when the installation is finished;

C_{OA} - Annual operation cost, paid at the end of each year;

C_{MA} - Annual maintenance cost, paid at the end of each year;

B_{EA} - Annual profit of electricity generation;

B_{RA} - Expected annual profit from the maritime research;

B_{TA} - Expected annual profit from new technology exploration;

B_S - The expected total reduction of economic loss caused by an extreme storm;

f_S - The frequency of the extreme storm, i.e., once per $1/f_S$ years;

r - Annual interest rate;

d - Annual degradation rate of the whole system.

Assume the life cycle of this system is the same with the expected interval of the extreme storm, namely, $1/f_S$ years, since after the mission of a shelter, the system must be overhauled.

The total operation and maintenance cost during one lifecycle is

$$C_{O\&P} = [\frac{1-(\frac{1+d}{1+r})^{1/f_s}}{r-d}](C_{OA}+C_{MA})$$

The total profits from electricity generation, maritime research and new technology exploration is

$$B_{E\&R\&T} = [\frac{1-(1+r)^{-1/f_s}}{r}](B_{EA}+B_{RA}+B_{TA})$$

The NPV (Net Present Value) is

$$NPV = B_{E\&R\&T} + B_S - (C_{O\&P} + C_I)$$

Based on this simplified life cycle cost model above, a rough evaluation could be made to judge whether this system is profitable or not. Since the frequency of the extreme storm is very low, perhaps once per hundreds of years, the realistic lifetime of the system might be much shorter than the expected interval of the extreme storm according to current technology. However, everything could happen in 2050. Therefore, it can be assumed that in 2050, the frequency of the extreme storm will be much higher due to the global meteorology change. Meanwhile new technologies will be developed to extend the lifetime of the system significantly. To be more accurate, a changing annual interest rate can be used instead of the fixed value in the simplified model.

7. Limitation:

Due to the limitation of knowledge and time, the interference of single functions of whole system has not been investigated yet. Besides, the inaccessible data like cost makes it hard to carry out the detailed analysis. Finally, compared to the original energy productivity, Nyheim has lower outputs since some space of converters are occupied by the crew area and facilities.

8. Future Prospects

Nyheim is not only designed as a countermeasure to disaster, but also an exploration of utilizing resources from the ocean in a creative way by use of advanced technology. Imaging the high housing density due to population booming and less livable land caused by global warming in year 2050 or future, there might be not enough place for human to live on land. However, since the ocean is still mostly a mystery for us, it could be of vital importance to the survival of all lives on the earth. Our team believes that it is a promising alternative for human to inhabit on the sea eventually due to limited space and shortage of crucial nutrient phosphorus. Therefore, all the technologies applied in Nyheim can be further developed to establish a comfortable "new home" for human beings in the long-term future.

9. Reference

[1] http://www.pelamiswave.com/pelamis-technology

[2] http://royalsocietypublishing.org/content/370/1959/365

[3] http://en.wikipedia.org/wiki/Tornado_warning