A design of low-carbon architecture near water under self-circulation system using dead water effect

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Abstract
The purpose of this research is to design a self-circulation residence near Greenland using fully renewable energy and dead water effect. Special values in terms of commercial for Greenland lead to the increase of local population. Previous investigations mainly study the particular dead water effect phenomenon neglecting the utilization of this influence, which may provide energy for local residence. This research implements electromagnetic induction to design a power generation equipment and self-circulation system. Final results show that the designed device could successfully produce power using dead water effect occurring in Greenland. In addition, a building utilizing self-circulation system is also devised to achieve energy circulation. In conclusion, dead water effect could be used to generate electricity and some special places have the potential to realize energy circulation.

Keywords: dead water effect; energy self-circulation; architectural space; renewable water energy system

1. INTRODUCTION
With the new trend of green buildings as well as the improvement of sustainability technologies, the characteristics of green buildings have been widely acknowledged by the general public [1–4]. In order to address the issues of global warming, carbon emissions and resource depletion, many scholars have gradually realized that energy saving alone is not the best way to achieve building energy efficiency especially for some buildings located at special climate zone [5–6]. Therefore, this article has put forward energy creation as a new concept that provides a solution to keep an energy conversion balance for water energy and to realize the goal of ‘zero energy consumption’ and ‘zero carbon emissions’ [7].

Urban land resources are gradually diminishing with the constant development of the built environment [8, 9]. However, >70% of the earth’s surface is occupied by water, showing great potential to be utilized—though it has not yet been done. Water is crucial for human life, and ocean covers 71% area of the earth. Currently, over one-third of the people resident within water-stressed countries all around the world, and, in 2025, this number is expected to increase to approximately two-thirds [10]. This huge population stress brings the challenge of water and fuel energy. Facing this issue, the maturity of desalination technology offers new solution to solve this problem. Desalination technology could efficiently enhance water supply, which is considerably different with traditional water reuse technology such as water conservation [11]. In the past decades, seawater desalination facilities have been apparently increased so as to augment water supply in water-stressed countries [10, 12, 13]. Two large-scale seawater reverse osmosis (SWRO) desalination plants recently had been installed in Spain [14] and Israel [15]. In the early phase, large-scale desalination devices, which mostly distributed in Gulf countries, process based on thermal technique and consume fuel energy in a high level dispersing large number of greenhouse gases [16, 17]. The new machine SWRO could figure out this problem well and reduce gases emission efficiently. Apart from this, the number of power driving for SWRO has diminished considerably in the past [10, 18, 19]. On the other hand, as the maturity of desalination technique, it also offers the drinking water solutions of coastal construction.

Water zones, especially the areas adjacent to coastline and inland waters, generally have good natural environment and rich resources, making them ideal places to live. Since the earliest settlements, humans have used the strategy of living alongside
water. Water has not only satisfied the requirements of living but also has helped manifest the idea of loving nature. In the history of civilization, all prosperous cities were settled near water zones. Examples of this are found in ancient Chinese civilizations on and along the Yangtze River and Yellow River basins, ancient Indian civilizations along the Ganges River basin, as well as ancient Egyptian civilizations along Nile River.

Figure 1 presents the various types of water building, which is divided by the relationship of position between architecture and water. Waterfront building refers to the architecture locating 200m along the bank. Waterfront building also includes near-water building that its one side faces aqua directly. In this case, sometimes one building side can extend into water and the other building part can still stay on the bank. Considering the relationship of architecture, water and land, the construction could be classified into three types too, off-shore building, semi-embedded building and embedded building. It can be seen from Figure 1 that off-shore building is positioned within water, which is ultimately encompassed by surrounding fluid. Semi-embedded building that refers to part construction is beset by the land and water, while embedded building means the only one construction side toward water and other sides face land.

This research aims to design a self-energy circulation system for off-shore building implementing special water effect explanation on the below. The self-circulation system of net-zero energy architecture is designed to locate on the east side of Greenland, as shown in Figure 2. Greenland is in the northeast of North America, between the Arctic Ocean and the Atlantic Ocean, covering an area of 216.6 km².

Greenland is located in cold polar climatic zone, and only temperatures in the southwest region slightly increase during the year if influenced by the warm current from the Gulf of Mexico. With a layer of constant cold air over the island, low-pressure air masses move from west to east, leading to ever-changing weather during sunny and snowy weather transitions. The temperatures during all four seasons are listed in Figure 3. However, the coldest central highlands region suffers the lowest mean temperature of $-43^\circ$C; therefore, this region is regarded as the second cold pole following Antarctica. The population growth and wind conditions are shown in Figures 3 and 4, respectively.

There are abundant natural resources in Greenland, especially in terms of onshore and offshore oil and gas. It is estimated that northeast Greenland region petroleum reserves more than 31 billion barrels, which is equivalent to 80 times that of petroleum
contained in Denmark’s North Sea. Additionally, lead, zinc and cryolite found in Greenland have great economic value. Vegetation in Greenland is primarily made up of tundra plants, including moss grass, sheep beard grass and lichen. Apart from Birch, willow and alder, which are low and small in size, other kinds of vegetation cannot survive in the limited ice-free area.

The main transportation is dependent on sleighs due to the snow and ice, with only a small area that being warm enough to have access to roads. Therefore, the main transportation of the country uses water and air. Ittoqqortoormit heliport and Nerlerit Inaat airport provide year-round air access and water-transport several months of the year, as shown in Figure 5. In addition, there are regular flights or mixed boats to three countries including Denmark, Canada and Iceland.

In summary, because of the requirement of resources transportation, it is indispensable to propose some scientific residential plan using self-circulation system based on the renewable energy. In this case, local indigenous residence could achieve the energy efficiency purpose under the premise of ensuring this place commercial value.

2. METHODOLOGY

2.1. Dead water effect
A significant design starting point against this research is dead water effect, which is often caused in the Greenland area. ‘Dead water effect’ occurs when a water layer has two or more layers with different salinities. For example, fresh water derived from glaciers forms thin layer water over high concentrations of seawater. Waves from the hidden layer will slow the velocity of the vessel without a trace as shown in Figure 6.

University of Lyon physicist Seri Daws and his colleagues investigated that the waves hidden in the water interface unknowingly chased the ship and slowed it down. In their experiment, the toy boat passes in a 300 cm depth sink pulled by a constant force provided by a cable. Sink water with different salinity and density was divided into two layers and marked by different colors. The surface of the water in the sink indicates very calm; however, the boat speed suddenly decreases when the hidden waves touch the ship just as the person who experienced the dead water effect during swimming. Researchers presented that a low pressure was formed under the ship and prevented the ship normal movement.

Scientists suggested that this was mainly because the water from the lower layer was drawn up to fill the vortex formed by ship movement, thus generating vibration at the interface of the second layer. The vibration intensity reinforces as the ship movement and finally hinders the travel of the vessel. Scientists also indicated that the wave constantly increased and accelerated, eventually catching up the vessel until it stopped the ship. Although previous investigations about dead water effect mainly studied the second layer water, it can be divided into several layers based on the different salinities in ocean seawater. When the researchers added the third aqua layer to experiments, the hidden waves appeared simultaneously in the previous two layers of water, which also diminishes the speed of the boat.

Studies have shown that these interfacial waves generated and formed by different water layers can help scientists understand the true ocean dynamics, such as the extent to which pollution can occur, and how deep the sediment will sink. The same effect can explain how swimmers have experienced unexpected difficulties in the ocean, and this effect may be a major cause of accidental drowning deaths. Dead water effect can explain the impediment
of navigation in polar region and help to solve some casualties' problems.

2.2. Dead water effect sensing device design
This article investigates a concept of device based on the dead water effect so as to remind this adverse function in the vicinity of ship and people. The operating principle for this device refers to utilize the electromagnetic phenomenon that occurs while wave breaks device. When ‘dead water effect’ occurs, the waves inside the ocean flow to the device, which in turn stimulates the equipment to cut the coil, thereby generating electricity to power the indicator light.

As shown in Figure 7, the sensing appliance is consisted of lighting, mounting plate, two electromagnetic equipment, counter weight and balance floating. Light uses for reminding surrounding people and ships the impacts of dead water effect. Simultaneously, mounting plate floats at the sea level providing temporary landing for the animals in the sea and those who are unfortunate enough to fall into the water. When the indicator lights up, the animals or the swimmer could climb the support board and wait for rescue after seeing the light.
Below the sea level, the whole device consists of two main wave interaction parts such as induction plate and electromagnetic equipment. The main function of the electromagnetic equipment performs to generate electricity by cutting coil; moreover, induction plate primary concentrates on the reaction of waves to magnify this effect. At the bottom of this device, the balance floating aims to maintain the whole appliance without overturning. Figure 8 presents the detail of lighting and electromagnetic equipment. All the coil and lighting are connected by the center axis tube, which covers the electric wire.

Figure 9 illustrates the appliance work flow:

Case a: in normal sea condition, device remains in stable situation without apparently vibration.

Case b: when animal or swimmer locates on the mounting plate, induction plate moves up and down pulled by the mounting plate. Hence, the two electromagnetic equipment shift to cut the coil and producing electricity to power the lighting. However, since the fluctuation of mounting plate only occurs on one side, the two coils in electromagnetic device remove on two contrary directions. The resulting current eventually counteracts each other due to the opposite direction. The indicator lighting would not light up in the end.

Case c: in this case, ‘dead water effect’ takes place underneath the sea level and waves generated by the different salinities on several layers flap induction plate. Mounting plate at the sea level remains steady and induction plate moves up and down simultaneously. Two wires in electromagnetic devices cut the coils in the same direction pulling by the induction plate. Therefore, generated currents transmit in the same direction and enhances by each other. Entire device holds steady condition based on the bottom balance floating. Figure 12 shows the device running performances.

2.3. Experiment design

In order to investigate and test the proposed instrument performance, a dead water simulation device was devised to realize above assumption. Karim et al. [20] performed an experiment to study the dead water effect in laboratory. This investigation tries to reappear this research equipment to realize dead water effect. In line with this device, a small model of electromagnetic induction instrument is assembled to achieve the generating function.

Based on the research of [20], a tank dimension size of $L \times H \times W$ with $200 \, \text{cm} \times 9 \, \text{cm} \times 20 \, \text{cm}$ is provided to be as vessel. In line with the dead water interior principle, it is necessary to make the water emerge multiple layers depending on salinity level. In this case, firstly, the entire height of water in tank is assigned as $h = 12 \, \text{cm}$. Secondly, for multiple layer water with different density, saline water solution colored by red or blue food dye is poured at the bottom of the tank for
the sake of visualization. Finally, along the wall of the container, clear water was poured slowly onto the water surface to decrease the mixture impact to produce quasi-two-layer density profiles. Under this circumstance, the layered liquid was realized with disparate density and color simultaneously to simulate seawater condition.

Focusing on this established instrument, related apparatus was implemented to measure the height of different layers and corresponding water density. The upper freshwater and bottom colored liquid’s height is 7 cm and 5 cm, respectively. Moreover, the density of water was under uneven situation and distributed at various locations as shown in Figure 10. In addition, Figure 10 also indicates the whole equipment condition. For the sake of dead water effect emerging, a timber cube of dimensions with 6 cm × 6 cm × 3 cm simulating a ship was towed by a fish line. A fixed pulley tool dragged the timber with fish line to move at the water surface to arouse the interior dead water wave effect. The invented device to be studied in this research was put at the water surface behind the timber cube. Noted that in such a narrow tank, the flow is practically 2D instead of 3D structure of the wake.

In this research, the significant stage is to electromagnetic coil power generation. Therefore, a model of electromagnetic coil instrument is indispensable for research as shown in Figure 11. It mainly includes four parts of magnet, coil, wire and LED light. Implementing aforementioned tank appliance, the aim of entire research is to make the LED go on under dead water effect. Meanwhile, four testing position points were set along the water surface to put instrument. Under this circumstance, the wave fluctuation function in different positions could be investigated. Moreover, so as to investigate this issue in quantitative, an ammeter was used to
measure the electricity condition. Figure 12 presents the electricity situation at different position of wave behind the timber.

2.4. Building construction

For buildings on water, the \( \text{H}_2\text{O} \) does not only affect the relationship with the location but also determines their functions, dimensions, structural forms, stress states, construction and operations [21, 22]. Therefore, the relationship between water and a building is based on the realization of the building's function [23]. Table 1 presents the different installation types for water buildings. For stationary buildings on water, the main structure is positioned above water level by erected piles, whose performance is greatly affected by water depth, water level change and water flow speed. Therefore, it is essential to keep intact the solidity of the waterbed when selecting the construction site, following the principles of hydraulic push reduction to satisfy both the requirements of upper limit of the water level and body scale. With regard to floating and semi-floating buildings, force-bearing calculation should be primarily conducted to ensure that buildings can sufficiently float above the sea level. The principles of floating buildings are quite simple when using the buoyancy suffered by submerged part supporting the expanse of the whole building. In general, the magnitude of the buoyancy is determined by the area of submerged structure and related to construction scales, structural patterns, materials selection, floating components and construction methods [24, 25]. These elements should be analyzed and simulated based on hydrodynamics calculations and experiments. Figure 13 provides a case of a semi-floating building titled Harbor Hub with a trapezium elevation. It is positioned on a longitudinal splint, floating at sea level. The longitudinal splint is equipped with a fish-grass shaped energy cycle device and light-emitting device.

Additionally, the coordination between the natural and artificial environment around buildings should receive great attention when it comes to water buildings. Harbor Hub is composed of five pieces of floating long splints, and its horizontal arrangements are separated in order and then connected through roads. On each splint, interior spaces with different functions are set up. These include a thinking tank and materials laboratory, a food production area, a restaurant, sharing cafes and hall, all bringing convenience to the users, as shown in Figure 14. As for dimensional composition, skyline control, color determination and material selection are not only controlled by the related technology but also represent an emotional expression of art. It works within no strict restriction, but rather starting from the notion of being environmentally conscious to meet the standards of environmental elements, functional requirements, energy conservation and environmental protection.

3. DESIGN AND MEASUREMENT RESULT

3.1. Energy self-circulation systems design

Water buildings are not only temporary shelters but also suitable living environments for residents [26]. Therefore, these buildings should be built to meet increasing sustainable design standards relating to the perspectives of nature, the environment, society, economy, science and technology. In regards to the natural environment, the most important principle should be environmental protection and respect for ecology. Energy saving refers to capturing wasted energy and reducing fossil fuel dependence needed for highly efficient technologies. Meanwhile, effective processing of waste emissions, appropriate use of energy and material circulation could reduce environmental pollution and increase energy efficiency [27, 28]. As for respecting the Earth's ecology and protecting animal and plant habitats, it is necessary to decrease the environmental burden and adverse impacts on animals, plants and underground water quality, as shown in Figure 15. In general, ecological sustainability does not include ecology and environmental protection and buildings constructed on water can provide space for development to improve user demands in order to meet the requirements of water-based traveling and enable flexibility of coping with urban change. Constructing livable spaces on top of bodies of water can potentially create more efficiency, ensure applicability and safety and even directly and/or indirectly influence positive economic effects.

Energy in water buildings is mainly consumed by air conditioning, heating and electrical loads. There are three methods of reducing energy consumption: green energy harvesting, employment of efficient energy management systems, low-carbon building and renewable energy utilization.

3.2. Passive energy-saving design

Passive energy-saving buildings refer to buildings that have relatively low energy consumption, depending on their self-equipped energy-saving technologies rather than mechanical and electrical equipment interventions [29]. In buildings, measures such as building orientation, lighting and shading techniques, natural ventilation and building facade can be used to achieve efficiency. The site conditions are primarily beneficial to energy saving [30].
Table 1. Different types for water buildings.

| Type       | Method                                                                 | Graph                                                                 | Application range                                                                 |
|------------|------------------------------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Stationary | It is a traditional type of waterborne building that is rigidly connected to a pillar or pile fixed to the bottom of the water and permanently. | ![Stationary Diagram](image)                                           | Adapt to areas where the water depth is small, the water level does not change much and the water flow is gentle |
| Semi-floating | Semi-fixed to the pile or pedestal, which can be lifted up and down with the water level | ![Semi-floating Diagram](image)                                         | The ideal form of construction in flood-prone areas, with strong adaptability to the environment and less restrictions on the upper buildings |
| Floating   | No support members at the bottom, all rely on buoyancy floating on the water | ![Floating Diagram](image)                                              | It can adapt to diversified scales and functions and is suitable for most aquatic environments. It is widely used in private floating houses and small water buildings. |

Compared with land, water has a larger heat capacity; therefore, it is conducive to temperature control. Secondly, the position of a floating water building is not fixed and with that it can rotate to regulate its orientation in order to receive appropriate day lighting and shading effects. The rotation of the building is likely to be affected by artificial drag and simple mechanical control. Additionally, water surfaces typically have an ideal wind environment, creating a good basis for natural ventilation. Apart from the environment, water buildings could reduce energy consumption starting from their energy management methods. Conventional energy-saving strategies are still applicable in water buildings as well. Reasonable planning and design is beneficial to
reduce building shape coefficients; reasonable utilization of insulation materials enhances the air tightness of doors and windows; building facade structures are beneficial to improving insulation performance, and even vegetation could be used to isolate the solar radiation [31]. These buildings’ energy-saving techniques are able to reduce the proportion and intensity of mechanical
control and thereby being the primary method of reducing energy consumption.

3.3. Renewable energy utilization

Renewable energy resources are abundant, have a wider distribution, provide convenience, are low-carbon producing as well as have less environmental impact; thus, it is recognized that renewable energy resources are ideal energy source for sustainable development. Currently, widely adopted energies include solar energy, wind energy, bioenergy, hydraulic energy and geothermal energy with solar and wind energies preferably suitable for water buildings [32]. There are two categories of methodology in water buildings relating to solar energy: solar heating and power generation. Solar energy is converted into heating through a solar heat collector in order to heat water and air for indoor heating. Power generation modules, however, convert solar energy into electricity through semiconductor materials. Wind energy in theory is the main sustainable energy resource in the open water environment. In general, different models of wind turbines meet the various construction needs and sizes. However, in reality, the minimum radius of small wind turbines is approximately two meters and they are always positioned at higher levels, causing issues such as construction difficulties and issues in building appearance and noise. Therefore, it is hard to utilize this technology in water buildings. Additionally, bioenergy technology can turn garbage produced into energy sources and wave absorbing converters can also generate electricity.

Figure 16 shows the energy self-circulation components that float around Harbor Hub. These kinds of component that float over the sea can self-illuminate at night, which enables them to warn the nearby boats that frozen water or ice is present in the stagnant water area. This can aid in avoiding damage to ships and other related accidents. What is important is the fact that the light apparatus does not consume additional energy. The energy needed for the lights is derived from specified generator...
units that produce electricity through the fluctuation of waves. In the day time, the loop components will automatically switch off, saving a large amount of energy. Similarly, excess energy will be transmitted to the Harbor Hub for lighting.

Potable water within buildings over water mainly comes from two channels. The first one is a collective water supply and the second one is a water collection, water treatment and water supply system, which has direct access to the water in the natural environment and is equipped to cope with drought conditions.

(1) Water collection and water recycling

The abundant water in the sea has provided convenience for water extraction in water buildings [33]. While water from rivers and lakes requires water decontamination to be potable, sea water can be used after desalination treatment. Nowadays, most large passenger vessels are equipped with seawater desalination systems, proving to be effective. It is well accepted that use of recycled water is the most effective method to save water and reduce wastewater discharge. Rainwater harvesting is a simple and effective method in supplementing available water supply, as shown in Figure 17. The slanting roof of Harbor Hub is useful in preventing snow accumulation, while combining collection and storage devices, to collect rain and melting snow. The water collected can be used in bathrooms and irrigation after a simple filtration process. However, the water sources have the disadvantages of intermittence and pollution risks. The secondary water reuse from the toilet, shower and kitchen can also help to realize additional water savings after collection and purification. Although a complete set of water treatment equipment cannot be accommodated in small water buildings, the use of some newer technologies, such as a water-saving toilet, can also achieve the same effects.

Figure 17. Rainwater collection and spontaneous light system.
(2) Sewage treatment

The water used in homes cannot be discharged into the natural environment without proper treatment and disposal. On the one hand, this can help to avoid water eutrophication caused by environmental pollution. In particular, water that cannot be recycled should be decomposed and processed through biological treatment and oxidation treatment, so as to be discharged into the river without organic matter and rich nutrients, while the rest should be centrally processed. On the other hand, water sources of buildings can also be protected. Some counties have developed a new type of dry ecological toilet, centralizing living garbage and excrement to gradually decompose sewage in motion based on the theories of fermentation and aerobic treatment. Therefore, the volume will be diminished without producing contaminations. This kind of method could save a large amount of water as well as deal with discharge pressure, suitable for water building promotion.

Water buildings are built solely for occupant consumption, but there also are many environmental advantages and opportunities to create new types of materials. Water buildings could utilize garbage to produce carbon dioxide, calories and nutrients to promote biofuels and food production. It is common to see that algae and kelp breeding around these buildings have adopted this kind of principle. Additionally, these algae farms and kelp beds could also prevent water buildings from waves. Algae can also be used as an effective source of biological energy. Certain algae containing >40% of grease can produce 10–20 times more biological energy than that of corn or sugar cane. Therefore, water buildings could be used for food production and aquaculture, or a combination of both, in order to ensure a stable environment in them. In accordance with the breeding system, planting vegetation in a cyclical system that combines aquaculture, nutrients, plants and bacteria can be useful in adopting a system where fish are used to purify water, to form a self-sufficient ecosystem. The amount and efficiency of protein produced are both higher and faster than that of protein on land. This could not only preserve a large amount of land but also help to save water—a multifaceted solution (as shown in Figure 17).

Water agricultural production attached to water buildings has become an important movement, offsetting the disadvantages of absent measures in coastal land and water area energy cycles. Production activities can be conducted within water, utilizing the waste nutrients ejected from surrounding land cities rather than artificial nutrients. Furthermore, the goods and materials produced from this process could be a food source for water buildings and land cities, while providing energy for self-circulation systems. Therefore, ensuring no environmental destruction issues caused while also providing a new approach for the sustainable city and its ecology. (Figure 18).

Through the extraction of carbon dioxide and nutrients from surrounding environments, sea water acidity could be stabilized. Not only would this reduce the threats to coral reefs and many biological habitats dependent on it, but it would also prevent the ecological water from abundant nutrients. In the ecosystem circulation, the outputs of aquaculture depending on water buildings are higher than traditional fishing. The result would significantly increase food supply and guarantee production stability. Thus, allowing for a sufficient supply of fish for food security, while leaving a healthy population of fish and other species to be protected. This method could be adopted to overturn global fish stocks and severe coral reef destruction caused by overfishing, all to aid in rehabilitating the water ecological system. Water buildings could
provide space for activities of aggregated dwellers, while at the same time provide desirable habitats for marine species to help improve diversity. Artificial underwater reefs are composed of renewable materials or waste materials, such as glass or metal. These kinds of underwater structures are more likely to maintain balance and stabilization, so as to effectively prevent disastrous situations. Additionally, shallow water areas resembling suitable habitats for most aquatic species can also be greatly enlarged, having significant benefits to the ecosystem by creating new habitats for species. (Figure 19).

3.4. Results of equipment operation

Figure 20 indicates the experiment result of created instrument. It can be obtained that the light had been successfully lit and interior wave aroused by dead water effect was also emerged. This phenomenon proves that the original design idea is correct. It can be attributed that the underneath wave fluctuation moves the magnet up and down, which lead to electromagnetic induction. In this case, the LED light is lightened by the electricity activated by the electromagnetic induction.

Figures 21 and 22 present the electricity condition for instrument during the period of experiment. It can be obtained that this equipment could produce electricity via electromagnetic effect. The generated electricity intensity decreases with the diminishing of the wave length. This is mainly because that the range of wave fluctuation up and down apparently influences the level of electromagnetic effect. The center of wave position has the largest maximum electromagnetic function. For example, electricity level of A point located at the middle of wave reaches 0.1A and the other electricity condition of position B to D attains between 0.01 and 0.08A. In addition, it should be noted that all the electricity located in a fluctuation and instability circumstance. In this case, the ammeter records the electricity condition in average.

4. DISCUSSION

This research focuses on the issue of building energy efficiency in particular circumstance. A self-circulation system is invented to integrated into architecture in order to implementing special renewable energy supporting building work. Based on the special ocean phenomenon in Greenland, power generation equipment is designed and tested in laboratory. The designed building integrates this instrument and other structure to establish entire energy efficiency system.

Focusing on dead water effect often occurring in special places, previous studies primarily investigated the principle of this phenomenon instead of utilization. This research implemented this work principle and invented equipment to achieve power generation utilizing this special ocean phenomenon taking fully consideration of local commercial value and shipping requirement.
In this investigation, significant designed equipment has been successfully achieved in laboratory. However, as the limitation of experiment condition, the model performed in this article is in small scaled situation. Future relative researches should be made to validate this instrument operation performance in actual size. In addition, apart from the power generation equipment, energy self-circulation building system currently stays in the theoretical process. So as to realize this ideal system, future investigations need to be done to cooperate with factory testing system energy efficiency performance.

5. CONCLUSIONS

With advances in scientific technologies and the progress of production methods, the design of water buildings has progressively improved under the multi-action of society, economy and energy technologies. As the architecture in this article focuses, many pilot projects have been carried out in cold glacier areas. Through the utilization of sustainable energy resources and appropriate techniques, energy in buildings could achieve energy equilibrium conversion, playing the role of environmental regulation. Through the analysis in this article, several conclusions have been achieved.

In the stage of urban planning and architectural design, solar radiation conditions should be analyzed to select suitable sun shading means based on the geographical environment and building orientation. In addition, natural ventilation, heat preservation and heat insulation should be conducted to reduce the energy consumed by refrigeration and heating. Water has a large heating capacity, causing water buildings to suffer from lower temperature swings compared with land buildings. Therefore, this kind of environment would benefit from regulated temperatures.

In Greenland region, a dead water phenomenon often occurs because of the local special ocean situation. In line with this condition, an extraordinary power generation instrument is developed and successfully achieved to service for ship and residence. It has significantly advantage for commercial shipping and swimmers when influenced by dead water around Greenland area, which could also be referred by other places with dead water condition.

The utilization of solar energy and wind energy could meet the basic living requirements in water buildings. Water recycled through rainwater collection and equipment storage could be used to rinse and irrigate after simple filtration processing. After collection and purification, secondary water from toilets, showers and kitchen can also be used for toilet flushing, realizing energy circulation. The unrecyclable sewage is expected to be biologically treated and oxidation treated to separate organic matter and rich nutrients, so as to discharge into rivers with the lowest environmental impacts. Artificial reefs are made up of renewable materials or waste materials, such as glass or metal. These kinds of structures could ensure the stability of buildings, preventing disastrous situations. Additionally, suitable aquatic organism habitats could be further enlarged.

DECLARATION

All authors contributed equally in the preparation of this manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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