

# Analysis on Structure of Interacted and Interconnected Micro Grid Based Energy Internet on Pelagic Clustering Islands

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**Abstract.** Compared with the direct access to the main power grid and diesel generators, this paper puts forward the scheme of using electric ships to shuttle between islands to transport electric energy, analyzes the limitations and defects of its application in offshore islands; and then puts forward a comprehensive energy supply system of offshore islands. The comprehensive energy supply system can make full use of the rich renewable energy of the islands, and realize the optimal allocation of the overall resources of the islands. At the same time, the energy supply system can break the isolated development pattern of island power grid and connect the island group power exchange ship. This paper analyzes the connotation and characteristics of the system, puts forward the key technology for building the integrated energy supply system of ocean island group, and gives the design and operation analysis example of power exchange ship.

## 1 Introduction

As most of the current island power grid research focus on offshore islands, those technologies are difficult to apply on pelagic islands due to the geographical differences between them. Furthermore, the current island power supply system design has several deficiencies including low utilization of renewable energy, unreasonable power layout, and lack of mutual support among island power grids [1].

The current offshore island power supply system can connect the mainland power grid with transmission lines, which will benefit the security and stability of the island power grid. However, either submarine cable or overhead line is with high cost, and its reliability is easily affected by the environmental factors, including extreme climate and occasional damage [2]. The power grid of pelagic islands is impossible to connect the mainland power grid by transmission line because of the high cost and technical difficulties. If the renewable energy of pelagic islands can not be fully developed, the local load will be maintained through frequent supply of fuel only, which is expensive, and more importantly not conducive to the sustainable development of the island [3].

The current island power grid can only meet part of its basic power demand, excluding fresh water, transportation power and other necessary ones [4]. Furthermore, the fishing radius of pelagic fishing is limited by the energy consumption of seafood processing and refrigeration. If pelagic islands can provide electric power for fishing boats and refrigeration service for seafood, the energy demand of fishing fleet will then be reduced largely, and the efficiency of pelagic fishing will

be improved. However, the current island power grid has little capacity for the loads mentioned above. In addition, renewable energy power generation may be in full capacity in the low load period, and the extra renewable energy that can not be consumed will be abandoned. Therefore, it is necessary to optimize the balance of power sources and loads of the island [6].

As the main power supply of the island, the diesel generator can be installed and maintained easily, but operates with noise pollution, greenhouse gas emissions and serious dependence on external remote periodic supply of fossil energy. With the development of renewable energy power generation technology in solar, wave and marine current energy resources, it is feasible to realize the island energy supply system based on renewable energy power generation. Due to the low (normally none) cost of renewable energy, only the cost of renewable energy conversion device is considered.

Due to the randomness and volatility of renewable energy power generation and the difference of natural conditions in different islands, the access of renewable energy to current island power supply system will bring new technical challenges to the current power grid design and operation. The construction of wind turbine and PV panel will occupy certain land, which is not feasible for the islands with huge population and limited land area. One can build large wind farms and solar power stations on the uninhabited islands near the island of load center. Island power grids that are not interconnected with the mainland power grid are usually isolated power grids. Due to the volatility of renewable energy power generation, large capacity controllable standby power supply (such as diesel generators) is needed for the island power grid, which reduces the

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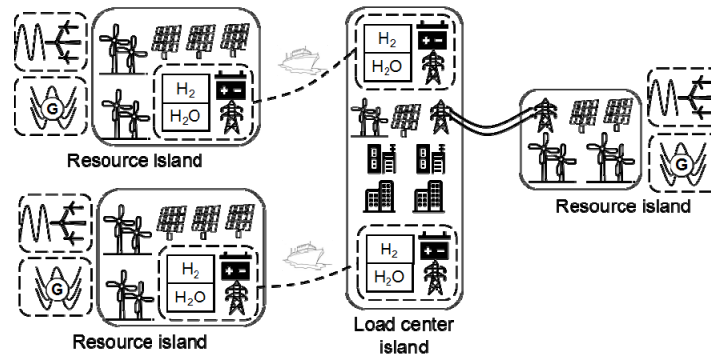
economy and introduces pollution. If the isolated power grids of several islands can be combined to form an integrated energy system of the pelagic clustering island by some means, the impact of the fluctuation of renewable energy to a single island power grid will then be reduced, and reliability of pelagic clustering island power grid will be improved.

The volatility of climate will easily affect the renewable energy power generation on the island due to its small capacity, which will then increase the difficulty of power generation prediction and power dispatch. Traditional power dispatch technology is mainly based

on the adjustable power supply. To adapt the volatility of renewable energy power generation on islands, new power dispatch techniques including load dispatch and energy storage dispatch should be combined to ensure the safety, economy and stability of the integrated energy supply system of pelagic islands.

## 2 Structure of energy internet of islands

Figure 1 shows the basic structure of energy internet on islands.



**Figure 1.** Energy internet of islands.

The cooperation of multiple power sources and loads with different characteristics in different period are the main issue for the realization of the integrated energy system of pelagic islands. However, the utilization efficiency of renewable energy including wind power, wave power and marine current power is limited by the difficulties on the prediction and dispatch in power generation and coordination of source-grid-load. Furthermore, the geographical characteristics in resources and loads will affect the modes on power transmission and transformation.

Therefore, the proposed integrated energy system in this paper is to take the pelagic clustering islands as an entirety and realize connection by power storage vessels with the consideration on the characteristics and limitations of the islands, hence realize the optimal allocation of the resources on islands and achieve self-sufficiency.

The load center island includes a main island and several satellite islands with small area and small population. The main power supply of the satellite island should be supplied by the main island power supply. The diesel generators in the satellite island is only used as emergency power supply. Generally, the main island and the satellite island is relatively close, which can be connected by submarine cable. The electric power on the resource island can be transmitted to the load center island through the transmission line when it is applicable, or generate electric power and produce hydrogen as well as fresh water, and then transmit them to the load center island by ship.

## 3 Case study

Resource enrichment island can provide multi-form energy support schemes and strategies to the load center island. This is because of the limited land area of the load center island, coupled with the noise and light pollution problems during the operation of new energy power devices such as wind and light, the new energy power generation devices are arranged in the resource enrichment island around the load island, and the load can be alleviated as much as possible by transforming the clean energy of the resource island. The power supply and resource supply pressure of the island and the clean replacement of diesel consumption are realized. Under such a production and supply layout, there are two feasible modes of power and material transportation between load island and resource island. One is to convert the clean energy on the resource island into electric energy, and then construct the energy link by means of cable and overhead line. But there are drawbacks to this approach. For example, the cable scheme may not necessarily have advantages due to the long distance between islands, low cable load rate and high installation cost; in addition, offshore islands are often located on the main sea route, and there may not be a prerequisite for the installation of cables between islands.

However, there is another construction scheme of wireless energy link between islands, that is, a new strategy of transferring the output of resource rich island through mobile energy storage: in addition to new energy power generation equipment, some controllable loads with high energy consumption (refrigeration, hydrogen production devices, etc.) can be arranged on

the resource enrichment island, and the electricity and materials produced on the island can be transported to the negative by freight ships Central island of the Netherlands. The development of high-efficiency local energy storage technology and the concept of energy Internet make it possible to realize the discrete transportation of energy by mobile tools with distributed energy storage as the carrier. Therefore, for the resource rich island without cable interconnection conditions, this scheme is a choice. For an offshore island group with an average load of 70mW, if all the power is supplied by traditional diesel, the annual energy supply price will be as high as 1.55 billion yuan considering the high price of oil and electricity caused by the difficulties in storage and transportation of offshore islands; assuming that the resource rich island can develop an average power of 30MW and the total transmission distance is 150 km The

annual energy supply price of renewable energy power generation base is about 13.7 percent, taking into account the loss, maintenance cost and equivalent annual cost of renewable energy equipment and submarine cable related facilities In the above scenario, if the power exchange ship is used to build the wireless energy link, the annual energy supply price will drop to 1.25 billion yuan due to the huge advantage of equal annual value cost of the ship compared with the submarine cable. Therefore, the development of renewable energy in resource rich island and reasonable selection of energy link construction mode are of great help to improve the economic level of the whole energy supply system.

For the further case study, 3 islands are illustrated in Figure 2, and the schedule of the ships are illustrated in Figure 3.

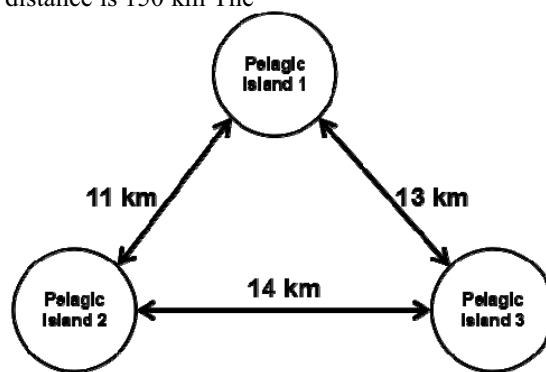


Figure 2. Case study for three islands.

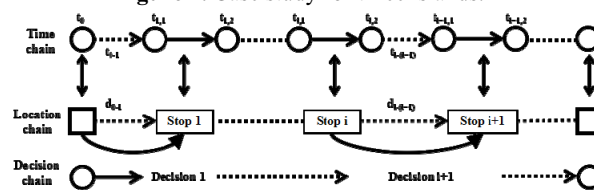


Figure 3. Ship schedule for the case study.

Due the the simulation by applying Monte Carlo algorithm, the charging and recharging of different ships can be illustrated in Figure 4.

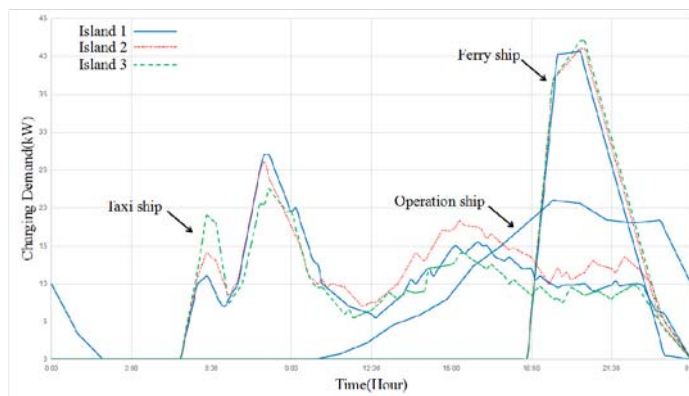


Figure 4. Charging and discharging of the ships.

## 4 Conclusions

This paper proposed the structure of an integrated energy system for pelagic clustering islands, and its technical

characteristics and the dispensable key technologies are both discussed in detail. The multiple types of ships including ferry ship, taxi ship and operation ship which are based on the proposed structure are analyzed with its operation and charging as well as swapping regulation in

a case study of pelagic clustering islands. The proposed integrated energy system introduces the large-capacity energy storage vessel and the utilization of unstable energy resources, which can make full use of the resources from different islands to achieve the self-sufficiency of island energy, and further guarantee the energy supply for the maintenance and development of pelagic clustering islands, as well as the implementation and application of the integrated energy system.

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