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21st Century Maritime Silk Road: Wind Energy Resource Evaluation

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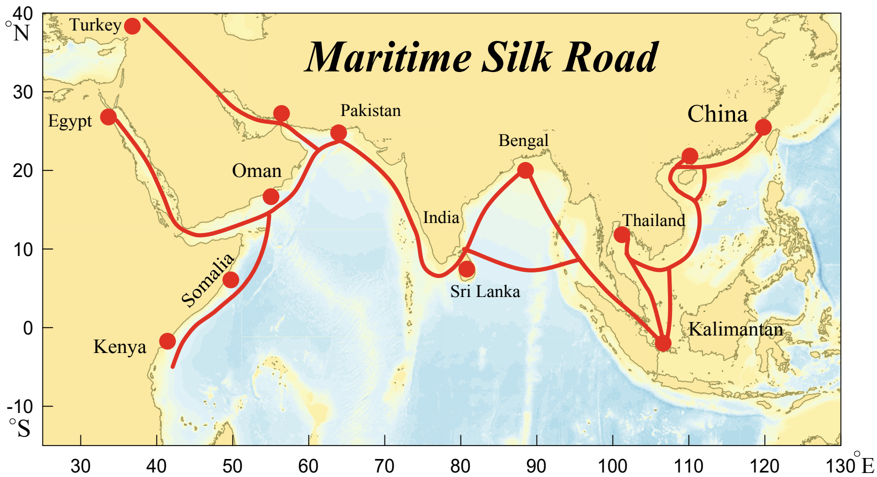

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Preface

As the energy and environment crises are accelerating, the smog and the deteriorating ecological environment have been gaining more and more attention nowadays. How to solve these crises has become the shared responsibility for all mankind. Today, conventional energy, such as coal and gas, is in severe shortage. Thus, marine renewable energy (such as offshore wind energy resource) will become the pillar to human society in the twenty-first century and support to our sustainable development. It will also be a new highlight for the Maritime Silk Road, and one of the best solutions to climate change and conventional energy shortage, as well as a good opportunity for international exchange and cooperation. At the same time, the marine renewable energy will also be an important support to realize the peak carbon dioxide emissions and achieve carbon neutrality. Most developed countries have passed laws and regulations such as tax reduction to encourage the development of marine new energy.

Offshore wind energy for years has been under the spotlight, as it eclipses others in terms of being safe, clean, renewable, abundant, widely distributed, as well as saving onshore space. Wind energy is very competitive considering the cost of the power generation and pollution management, as the industry is advancing with the rapid progress in technologies. Using wind power to generate electricity is the main method to exploit this new energy. Besides that, it is also applied in desalination, navigation, and wind heating. In coastal areas, high GDP has also brought high pressure for electricity supply. Thus, by exploiting the offshore wind energy according to local conditions, local authorities could effectively respond to the energy crisis and promote sustainable development of local communities. As for remote islands and reefs, which are in desperate need of electricity, utilizing marine resources and exploiting offshore wind energy could not only fill the gap of power supply, but also protect the ecological environment, avoiding the pollution caused by diesel engines.

In most cases, remote islands are an important support for deep-sea exploration. As these islands are far away from the continent, generating electricity under such a condition has always been a global challenge. Diesel, delivered by ship, has served as a common solution for remote islands to deal with the energy crisis, but it is not without its problems: The supply lines are too long and could easily be subjected to extreme weather; the ecological environment on such islands is too fragile to be restored once polluted by diesel engines. Thus, offshore wind energy and desalination programs could be an antidote to the power shortage and a blessing to island dwellers and countries along the Maritime Silk Road which are facing energy and environment crises.

Currently, onshore wind power generation technologies are relatively mature. However, when it comes to offshore, only few countries are equipped with mature technologies, while wind power generation in most countries and regions is still in its infancy. Besides, wind power varies hugely in different regions and seasons. Therefore, one of the basic principles for massive wind power development is "evaluation of resources and planning go first." Based on solid and detailed wind power evaluations and planning which covers its development and grid construction, we could well manage the wind power and exploit it effectively.

This book aims to establish a wind energy evaluation system, to provide scientific research for site selection, daily operation, and long-term planning of wind power generation. Firstly, we analyze the advantages and disadvantages of offshore wind power, then further discuss the status quo and challenges for wind power programs along the Maritime Silk Road, and offer suggestions. A wind energy evaluation system was proposed with the Maritime Silk Road as a case study, including climatic features of wind power (temporal–spatial distribution), long-term climatic trend and mechanism, short-term forecast of wind energy, mid- and long-term projection of wind energy, technology of wind energy evaluation on key point or vital region, and offshore wind energy dataset construction, to provide systematic and scientific reference for wind power evaluation and utilization. We hope the research could make contribution to easing the energy and environment tension, promoting the living standards of people along the Maritime Silk Road and break the shackles of power shortage.

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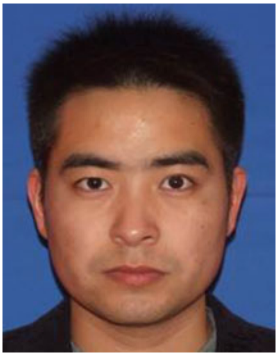

Dr. Chongwei Zheng obtained his Ph.D. degree in Atmospheric Sciences from National University of Defense Technology. He is the creator of Marine Resources and Environment Research Group on the Maritime Silk Road. His research fields cover physical oceanography, marine new energy evaluation, wind and wave climate, climate change, air–sea interaction, and so on. He has published more than 90 papers in many peer-reviewed journals as the first author or corresponding author, including 38 papers indexed by SCI and 15 papers indexed by EI. He has published six books as first author. He is a reviewer for more than 40 high-impact journals (including Renewable and Sustainable Energy Reviews, Applied Energy, Remote Sensing of the Environment, etc.). He is also a monograph reviewer for Elsevier. In 2017, his project titled "Wave energy and offshore wind energy resources evaluation of the Maritime Silk Road" won the Marine Engineering Science and Technology award from the China Association of Oceanic Engineering.

Prof. Hui Song was born in Laiwu city, Shandong Province, in 1969. He got the master of engineering in Navigation Technology from Dalian Naval Academy in 1996. He has studied abroad at the Collège Interarmées de Défense (CID). His research interests include the navigation technology, education and teaching methods, innovative talent training, and so on. He is mainly engaged in the teaching research and teaching management in the field of navigation. In recent years, he has won the first prize of Chinese National Teaching Achievement Award. He has published six academic research papers on navigation and education management. He has also published one academic book on navigation and education management.

Prof. Fang Liang is doctor and doctoral supervisor at the National Security College of China National Defense University. She graduated from the National Defense University with a major in Operations Research. In 2015, she was awarded the honorary title of National March 8th Red-Banner Pacesetter, a director of the Chinese Ocean Society, and the Deputy Secretary General of a discipline Professional Committee of Oceanographic Society of China. She has long been engaged in teaching and research in the fields of ocean planning and design. He has published many books such as the academic monograph "On Important Maritime Channels." She published more than 60 academic articles. In 2020, she won the national second prize of the National Vocational College Teaching Ability Competition.

Ms. Yi-peng Jin graduated in 2019 with a master degree in foreign linguistics and applied linguistics from the Graduate School of Translation and Interpretation (GSTI) in Beijing Foreign Studies University and is a translator currently based in Beijing. She is now working at the RDFZ Aeroplane School as an English teacher. Her research field covers major areas in translation and simultaneous interpretation. She also received her bachelor degree in BFSU in international relations and diplomacy. She is qualified as a CATTI Level II interpreter and has won the second place in 2019 GSTI Interpretation Competition. During her time at school and after graduation, she's been active in various fields of translation and interpretation. She served as the simultaneous interpreter for the 2019 China International Fair for Trade in Services (CIFTIS) and has also provided interpretation and translation for United Nations Development Program (UNDP), Federation of University Sports of China, Destination Canada, RDFZ, and many other institutions.

Mr. Dong-yu Wang , 41 years old, is Director of the Wanglan Marine Technology Institute. He has a Master's degree in Ocean Engineering from South China Sea Institute of Oceanology, Chinese Academy of Sciences. During his work at the South China Sea Institute of Oceanology, Chinese Academy of Sciences, Wang served as an assistant researcher in the research group of Dr. Zhang Jingxiang, a senior engineer of marine buoys and submerged buoy research and development, and participated in Dr. Zhang's several projects including large-scale deep-sea buoy, the preliminary investigation buoy and mooring system of the Hong Kong-Zhuhai-Macao Bridge, the South China Sea Petroleum Development Zone survey buoy subject, etc. He won two second prizes and three third prizes for scientific and technological progress by Chinese Academy of Sciences and Guangdong Academy of Sciences, respectively. He obtained several invention patents, including the double-buoy system, small wave generator, high-efficiency wind power generation, and more than 20 utility model patents.

Dr. Yu-chi Tian was born in 1990, and he got a double master degree in biomedical engineering from and Northeastern University in China and University of Dundee in UK, respectively. And he is studying for a doctorate degree in biomedical engineering at Fudan University now. His research field is focused on artificial intelligence and medical treatment and health. He has obtained the "Dean Scholarship" in University of Dundee, UK, in 2016, and has been awarded the Award for Outstanding Ph.D. student as Fudan University for the academic year 2019–2020. He has hold on a project of campus resource linkage platform funded by Fudan

Fanhai Venture Foundation. Also, his research project of “Prediction and evaluation of the effect of HCC immunotherapy based on MRI imaging” won funding from the Yunfeng Foundation.

Chapter 1
Introduction

A community with a shared future for mankind has been advocated by China with pragmatic development initiatives, one of which would be the Maritime Silk Road. It is a major step forward, an initiative that could not only benefit people along the Road, also a blue belt that links the Chinese dream with the global one (Zheng et al. 2018a, 2018b). However, there are many difficulties in the construction process. The Maritime Silk Road covers a long route and vast sea areas with complex natural conditions, and outdated infrastructure, lack of oceanographic data and basic studies have all been severely constraining our abilities to research, explore and exploit marine resources. The overall fragile power supply along the Road has been a barrier to the building of the Maritime Silk Road. Generally speaking, the total power consumption along the Belt and Road Initiative is only 61% of the world's average amount (Jiang et al. 2019). The key to effectively building the Maritime Silk Road is to solve the electricity crisis.

The offshore wind energy, large in amount, wide in distribution and available under all conditions, can be applied to power generation and desalination, as well as water pumping, wind-heating and other projections (Soukissian and Papadopoulos 2015; Xydis 2015). And it provides strong power support to the building of the Maritime Silk Road. It is not only one of best choices to break the crisis but also a blessing to marine ecological protection, people living along the Road and the exploration of remote sea areas. It provides a good opportunity for international exchange and cooperation and an antidote to climate change and conventional energy shortage. At the same time, the offshore wind energy will also provide important support for mandkind to achieve the carbon neutrality target. As wind power variables hugely in different regions and seasons, one of the basic principles for massive wind power development is "evaluation of resources and planning go first". Based on solid and detailed wind power evaluations, we could well-manage the wind power and exploit it effectively.

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1.1 Advantages of Offshore Wind Energy

The deteriorating energy and environment crises have been severely threatening the living and sustainable development of all man-kind. Currently, conventional energy such as coal and oil has becoming more and more scarce, and humans are putting new hopes on new energy which is safe, clean, renewable, abundant and widely-distributed. With the advancing of technologies, wind power will be extremely competitive considering the external cost of power generation and pollution (Junginger et al. 2004; Blanco 2009). Wind energy is mainly used for power generation, as well as desalination, navigation, water lifting, irrigation, heating, etc. Offshore wind energy has the following advantages (Zheng 2011):

(1) Remote islands and reefs are an important support for marine exploration. However, remote islands and reefs are in desperate need of electricity. Utilizing marine resources and exploiting offshore wind energy could not only fill the gap of power supply, but also protect the ecological environment, avoiding the pollution caused by diesel engines, thus to significantly increase the living conditions and promote their sustainable development as offshore strategic spots. Besides, it can also empower beacons and buoys so as to decrease the relevant cost for maintenance.
(2) Adequate infrastructure is the prerequisite for commercial development on remote islands such as tourism. Exploiting off shore wind power according to local conditions could not only serve as an antidote to power shortage, but offshore wind farms have become beautiful tourist attractions themselves and could contribute to economic growth. Furthermore, adequate infrastructure could increase the living standards of dwellers and ease the energy and environmental crisis for countries along the Road and in turn promotes its own development.
(3) Compared with onshore wind power, offshore wind power could generate more electricity: the wind speed 10 km off the coast is 25% higher than that along the coast and suffers less influence. Usable wind power resources are 3 times larger than those onshore (Tambke et al. 2005; Wang et al. 2015; Yao et al. 2007), which promotes better collection and transformation of those resources.
(4) Offshore wind power saves land resources and the trouble to relocate residence, which would otherwise prove to be a heavy cost. It also minimizes the noise and light pollution and has little influence to human activities.
(5) The height of the wind turbine towers can be reduced and so does the cost of the turbines, as the ocean surface is less rough with smaller friction and smoother underlying surfaces and higher wind speed at lower altitude.
(6) The service life of turbines offshore can be prolonged to 50 a in design and their bases can be recycled, as the low turbulence intensity and small friction of the sea surface wind (Li and Yu 2004).
(7) Technology for wind power generation is rather mature and ready for mass commercial exploration. And the technology would be continually advancing