Renewable Energy 120 (2018) 151–162

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Site selection for offshore wind farms in the southwest coast of South Korea

Choong-Ki Kim, Seonju Jang, Tae Yun Kim*

Korea Environment Institute, South Korea

ARTICLE INFO

Article history:
Available online 28 December 2017

Keywords:
Offshore wind farm
Site selection
Decision-making support tool
InVEST

ABSTRACT

This study is to provide guidance for selecting sites suitable for offshore wind farm developments with lower social, economic, and environmental impacts in the South Korea southwest coastal area with its complicated shoreline configuration, large ecologically important tidal flats, and various marine-based human activities. To analyze the economic feasibility of offshore wind farms, harvestable energy was calculated using an InVEST (Integrated Valuation of Environmental Services and Tradeoffs) model that has been used widely for marine ecosystem service analysis. Capital costs for grid connection and electricity transmission, operation and maintenance costs, and other costs were integrated together to calculate a net present value (NPV) of a 60-MW offshore wind farm assuming a lifetime of 20 years of operation. It is important to note that NPVs of offshore wind farms are affected significantly by the proximity to the closest inland substations, showing the importance of grid connection. Criteria that may cause social and environmental conflicts were grouped into three categories: nature conservation and landscape protection, marine-based human activities, and marine environment and marine ecosystem. Available datasets for each category were compiled and incorporated into GIS-based maps. Many social and environmental criteria overlapped spatially, and areas influenced by one or more criteria were designated as areas of potential conflicts. Economic analysis results and potential social and environmental conflicts were considered together to select areas that could produce wind energy more efficiently with minimum social and environmental conflicts. Economic, social, and environmental assessment strategies and procedures provided in this study can be used as an effective decision-making support tool to find sites for offshore wind farm development and various other offshore developments as well.

1. Introduction

The Paris Agreement was adopted as a result of the 21st Conference of the Parties of the United Nations Convention on Climate Change in 2015. At this conference, the South Korean government put forth goals to reduce greenhouse gas emissions by 37% from the business-as-usual (BAU) level by 2030 [20]. Electricity generation capacity increased by 50% in South Korea over the 10 years prior to the study due to continuous economic growth. In order to provide reliable and steady electricity to all sectors of consumers, demand for additional coal burning power generation plants has increased. In order to meet the increased demand for electricity with a reduction of global warming gas emission, the Korea Ministry of Trade, Industry and Energy (KMOTIE) decided to increase the generation of electricity from renewable energy while cutting down the number of new coal burning power plants from 12 (10.8 GW) to 8 (7 GW). They also set a goal to increase the share of renewable energy, with a focus on solar and wind energy, up to 13.4% of the total electricity generation by 2035 [18]. To achieve this goal, it is planned to increase the share of electricity generated by wind power up to 28 times that generated in 2012 [27]. In South Korea, however, sites suitable for land-based wind farms are very limited as a large fraction (more than 70%) of its small land mass (40,000 km^2, ranked 109th worldwide) is covered by forests. In addition, most nonforest areas are already being used by more than 45 million people, making it further difficult to find optimum sites to construct land-based wind farms [7]. Due to these difficulties in finding suitable sites, many land-based wind energy development projects currently being implemented have caused various social and environmental conflicts (e.g., ecological habitat destruction

* Corresponding author.
E-mail address: kimty@kei.re.kr (T.Y. Kim).

https://doi.org/10.1016/j.renene.2017.12.081
0960-1481/

and fragmentation, habitat connectivity alteration, deaths of birds and bats from collision with wind turbines, conservation area damage, and noise produced by rotor blades).

Offshore wind farms cause less environmental impairment compared to their land-based counterparts, and are considered emerging renewable energy more suitable for South Korea with its east, west, and south borders surrounded by the ocean. The Korean government is planning to build offshore wind farms to generate 2.5 GW of electricity [17]. The southwest coastal area has a complicated shoreline configuration with more than 2000 islands (Fig. 1). Significant fractions of this area need to be excluded for wind farm development due to various social and environmental conflicts. Some large tidal flats in this area near Gochang-Gun, Jeongdo-Gun, Muan-Gun, and Seocheon-Gun have been placed onto the List of Wetlands of International Importance, also known as the Ramsar List [30]. The Shinan Dadohae Biosphere Reserve, designated by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 2009, consists of more than 1000 islands and large tidal flats with rich biodiversity and provides important habitats for marine lives and rare migratory birds. Many parts of the southwest coast also are protected as Marine National Parks, Natural Environment Protection Zone, and Fishery Resources Conservation Zone, and have been used for small-scale fishery and aquafarms and for shipping routes [28]. When developing offshore wind farms, social and environmental factors need to be considered seriously together with economic factors. As the distance from inland substations increases, water depth also increases, leading to a significant increase of capital costs for wind turbine installation and electricity carrying cables. Therefore, it is a big challenge to construct 2.5-GW wind farms in the southwest coastal area while balancing social and environmental impacts and economic feasibility.

Prior to constructing large-scale offshore wind farms, it is very critical to inform the stakeholders why wind farms need to be constructed in certain sites and gradually form a social consensus. It is also important to build a system that can incorporate the opinions of stakeholders in advance when planning large-scale construction projects. In order to support and facilitate the decision-making process for selecting sites suitable for offshore wind farm construction, it is important to use a variety of knowledge- and data-based tools that can provide meaningful information regarding social, environmental, and economic acceptability.

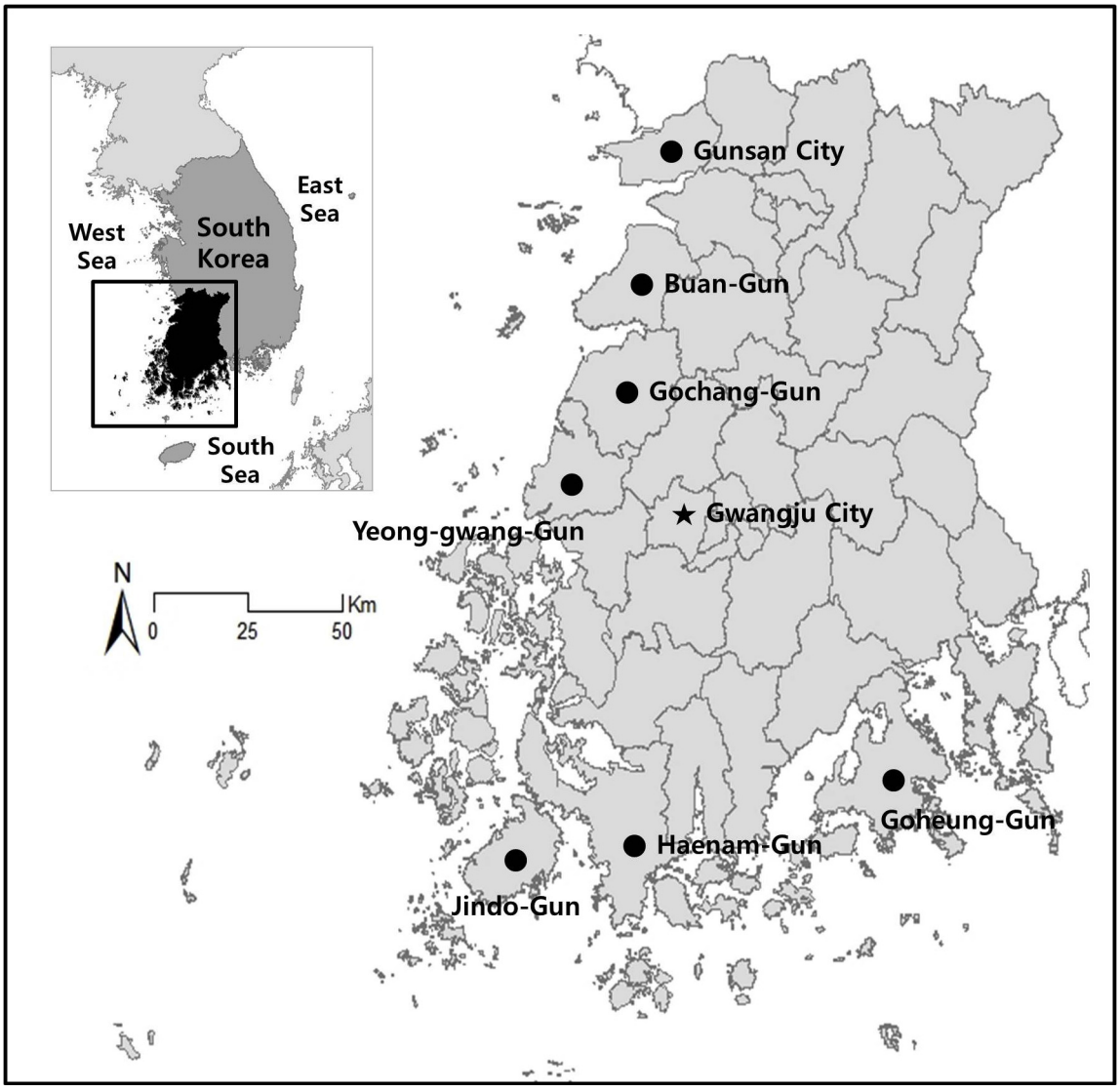

Fig. 1. A map of the southwest coast of South Korea.