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Freshwater and Lithium from Desalination Powered by Marine Energy Sources

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To our knowledge, this paper represents an initial study of a novel concept in freshwater and lithium extraction from desalination powered off-grid by marine renewable energy sources. The project's background is interest in the local supply of lithium for the growing numbers of electric vehicles. The desalination technologies investigated are reverse osmosis and electrodialysis. The collocation of the marine resources, possibly available and future technical solutions, and demands for freshwater and lithium suggest that the proposed system could be interesting to study further.

INTRODUCTION

Desalination of saltwater can produce freshwater. This is an energy-intense process wherein renewable energy sources (RESs) could be utilized. The residue of the desalination process is a high-salinity solute called "brine" or "concentrate." Potentially, useful minerals could be extracted from the desalination brine (Swain, 2017). With the ongoing electrification of the transportation sector, there is an increased interest in battery materials for electric vehicles, such as lithium (Narins, 2017; Speirs et al., 2014). Electric vehicles are expected to make up roughly one third of the world's passenger vehicles in 2040 (Bloomberg NEF, 2019). The objective of this study is to initiate an investigation of lithium extraction and freshwater production from desalination powered by marine RESs.

LITHIUM

Lithium, used for lithium-ion batteries, is part of the technical development of electromobility (i.e., electric vehicle batteries), balancing energy storage units as more RESs are connected to the grid, and small electronic devices, such as mobile phones. The increase in electric vehicles is expected to result in an increase in lithium battery demand by 70×, and the batteries for stationary energy storage are forecasted to grow 122×, until 2040 (Bloomberg NEF, 2019). Today, only a few countries and companies sell lithium: 70% of lithium-brine resources are located in Argentina, Bolivia, Chile, and China (Kesler et al., 2012). China was the producer of more than 60% of the global lithium supply in April of 2019, whereas the United States produced 1% (Sanderson, 2019). Lithium can be extracted from naturally occurring sources of high-salinity brine and minerals, and also from clay and seawater. Furthermore, interest in recycling of lithium-ion batteries for the purpose of reusing the lithium may increase. While a global supply shortage of lithium is much feared, it has been suggested that a future shortage of lithium could be avoided if it were to be extracted from the oceans to a greater extent (Narins, 2017). The lithium concentration in seawater is low, meaning that seawater requires substantial processing (Swain, 2017). However, seawater contains the largest amount of lithium to be found on Earth: lithium availability in the oceans is estimated at 230–240 billion tons (Shahmansouri et al., 2015). The amount of lithium in seawater varies globally at different locations; it is estimated at a mean value of 0.17 ppm (Vikström et al., 2013). Technical solutions to decrease water scarcity and produce freshwater (i.e., desalination) could potentially be used for aqueous mining (extracting, e.g., lithium). Lithium extraction by electrodialysis (ED) from different sources was recently summarized and presented (Gmar and Changes, 2019). Although ED is used commercially for seawater desalination, its use for lithium extraction has been investigated only for small samples.

DESALINATION

With desalination, salt is removed from salty water (e.g., brackish water, seawater, or wastewater). Two different desalination technologies available, suitable for marine RESs, are ED and reverse osmosis (RO). In ED, a process that includes membranes, an electric field is applied to the water, and ions of salt will move to an anode or cathode. In RO, feed water is pushed through semipermeable membranes by pressurizing water on one side of the membrane. How much freshwater (permeate) and concentrate (brine) that is generated from a specific amount of feed water depends on pressure applied to the water, salinity of the inlet water, and performance of the RO membranes, etc. RO is the most common desalination process, producing approximately 69% of the desalinated water in the world (Jones et al., 2019). The energy demand of desalination is often high, and the energy source utilized affects the overall sustainability of the desalination plant. Power variability for the RO desalination plant may have negative effects on the membranes due to variable pressure and water

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KEY WORDS: Wave power, marine current energy, desalination, lithium-ion battery, electric vehicles, aqueous mining, brine management.