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Forward osmosis for applications in sustainable energy development

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ABSTRACT

Forward osmosis (FO) provides a method of harvesting the osmotic potential difference between fresh and saline waters to produce electricity. FO occurs when fresh water and saline water are placed on opposite sides of a semi-permeable membrane. When this occurs water naturally flows from the freshwater side of the membrane to the saline side. This water flux continues until the osmotic pressure difference on both sides of the membrane equalize. The water flux will cause the pressure to increase in the saline water. If the saline water is seawater the pressure can reach as high as 410 psi. This pressure can be harvested as hydraulic power, similar to that of a hydroelectric dam. Such a system is called pressure retarded forward osmosis (PRO) and it can be used anywhere fresh water mixes with saline water. The worldwide potential energy of this resource, based on locations where rivers mix with oceans, is reported to be in excess of 1600 tera-watt-hour (TWH) per year [1]. In arid regions, such as California, where few major rivers reach the ocean, the applicability of PRO is limited. In these regions it makes sense to look for alternative sources of fresh water. This project evaluates an approach where, rather than siteing a PRO power plant in ways that potentially impact sensitive costal environments, they are sited at wastewater treatment plants that discharge into the ocean or other sources of saline water and are effective in a comprehensive environmental management and design role. Electricity can then be generated from the mixing of the treatment plants outfall and seawater while providing a high level of additional treatment and environmental protection. In the state of California alone, 1,350 million gallons per day of treated municipal wastewater is discharged into the Pacific Ocean. Using PRO this represents about a 26 megawatt resource. In addition to the electricity produced, the PRO also provides tertiary treatment of the wastewater treatment plant's outfall. It is comparable to treatment with reverse osmosis membranes. The combination of PRO and tertiary treatment (PRO/TT) provides the mutual benefit of sustainable power production and advanced wastewater treatment. This is particularly important in locations where regulation is requiring treatment plants to tertiary treat wastewater. PRO/TT can be used to offset the cost of providing treatment by generating electricity that can be sold for profit or used to help power the treatment plant.

Keywords: Forward osmosis; Pressure retarded osmosis; Osmotic power; Osmotic wastewater treatment; Water/power nexus

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