Energy-efficient water purification

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Water and energy are two resources on which modern society depends. As demands for these increase, researchers look to alternative technologies that promise both sustainability and reduced environmental impact. Engineered osmosis holds a key to addressing both the global need for affordable clean water and inexpensive sustainable energy according to Yale researchers.

Yale doctoral student Robert McGinnis and his advisor Menachem Elimelech, Chair of Chemical and Environmental Engineering, have designed systems that harness the power of osmosis to harvest freshwater from non-potable sources, including seawater and generate electricity from low-temperature heat sources, such as waste heat from conventional power plants.

Yale University is commercializing their desalination technology through a newly-established company, Oasys. Their approach, which requires only one-tenth the electric energy used with conventional desalination systems, was featured in the December issue of Environmental Science & Technology.

"The ideal solution," says Elimelech, "is a process that effectively utilizes waste heat."

According to the authors, desalination and reuse are the only options for increasing water supply beyond that which is available through the hydrologic cycle — the continuous movement of water on, above, and below the surface of the Earth. However, conventional desalination and

reuse technologies use substantial energy.

Using a new twist on an old technology, the engineers are employing "forward osmosis," which exploits the natural diffusion of water through a semi-permeable membrane. Their process "draws" pure water from its contaminants to a solution of concentrated salts, which can easily be removed with low heat treatment — effectively desalinating or removing contaminants from water with little energy input.

Another application of engineered osmosis the Yale researchers are pioneering, the osmotic heat engine, may be used to generate electrical energy. Elimelech and McGinnis say that it is possible to produce electricity economically from lower-temperature heat sources, including industrial waste heat, using a related method — pressure-retarded osmosis. In this closed loop process, the "draw" solution is held under high hydraulic pressure. As water moves into the pressurized draw solution, the pressure of the expanded volume is released through a turbine to generate electrical energy. The applied hydraulic pressure can be recovered by a pressure exchanger like those used in modern reverse osmosis desalination plants.

"The cost of producing electricity by this method could be competitive with existing means of power production" says Elimelech.

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