

PX PRESSURE EXCHANGER FOR REDUCED ENERGY USE IN LITHIUM APPLICATIONS

Lithium demand is expected to rise rapidly to serve the energy transition, especially for battery production. Extracting and processing lithium can be highly water and energy-intensive, in some cases requiring limits on wastewater discharge to meet environmental regulations. Reverse osmosis (RO) with PX® Pressure Exchanger® technology can boost energy savings at multiple points across the lithium battery value chain to enable lower cost, more efficient lithium extraction, and sustainable wastewater treatment.

Energy Recovery (Nasdaq: ERII) stands out as a global leader in energy efficiency technology. Leveraging our pressure exchanger technology platform, we provide solutions to tackle key challenges in the lithium battery value chain. Our solutions not only enhance efficiency but also reduce the energy consumption of RO, making it a cost-effective choice for lithium brine mining, direct lithium extraction (DLE), and wastewater treatment.



APPLICATIONS

- LFP cathode manufacturing
- Battery recycling
- Lithium brine mining, including direct lithium extraction (DLE) and non-DLE

BENEFITS

- Reduce capital expenses
- Lower energy use and operating costs
- Comply with environmental regulations
- Pressure and temperature recovery





Lithium Brine Mining

Lithium is often found in brines or salt lakes throughout parts of China, South America, and the United States. To extract this mineral, water is pumped out of the ground and into massive evaporation ponds, which rely on basic evaporation to concentrate lithium salts. Some lithium producers have turned to reverse osmosis to speed up the concentration process, reducing the time to days (often with DLE) versus years with evaporation ponds only. Combined with Energy Recovery's PX technology, reverse osmosis can efficiently recover lithium from the brine, save energy, and reduce costs.

Benefits of Low Energy Membrane Concentration Systems with PX

- Reduce the required land size
- Enable faster lithium recovery
- Lower energy use, operating costs, and emissions



APPLICATION OF HIGH-PRESSURE PX (CASE STUDY)

Energy Recovery's PX reduced electricity usage by half in a low salt rejection reverse osmosis (LSRRO) process to refine and concentrate lithium salts at the Zabuye Salt Lake in Tibet. Using membranes reduced the solar evaporation time by half, doubling the production rate. PX technology reduced energy demand by 2.3 MW, which lowered the cost of the new concentrating solar power (CSP) power supply by ~\$10 million USD.* The combination of CAPEX and OPEX savings related directly to PX technology significantly reduced the unit cost of extraction for lithium bicarbonate at this site.



Direct Lithium Extraction (DLE)

DLE involves novel processes to extract lithium from brine. After initial extraction via a DLE system, nanofiltration or low-pressure reverse osmosis (LPRO), high-pressure reverse osmosis (HPRO), either ultra-high pressure RO (UHPRO) or osmotically assisted RO (OARO), and evaporators are often used to concentrate lithium chloride (LiCl) before further conversion to lithium carbonate and lithium hydroxide.

Benefits

- Increase water and energy efficiency
- Get rapid payback to reduce energy use and post-DLE processing costs
- Increase efficiency of lithium and brine separation = smaller footprint

APPLICATION OF PX U40 (CASE STUDY)

At one of the first commercial DLE projects in the Qinghai province of Central China, LPRO, HPRO, and evaporators were initially used to concentrate lithium chloride after resin-based DLE extraction. During a plant expansion, UHPRO with two PX U40's was added in between the HPRO & evaporation systems to concentrate LiCl in lieu of adding new evaporators. This significantly reduced CAPEX, OPEX, and energy consumption before conversion to lithium carbonate and lithium hydroxide. PX technology was thus able to significantly reduce the levelized cost of electricity (LCOE) of lithium products from this site.

**Actual results may vary*



PX PRESSURE EXCHANGER FOR REDUCED ENERGY USE IN LITHIUM APPLICATIONS

Lithium Battery Manufacturing

Producing components for lithium batteries, such as lithium iron phosphate (LFP) cathodes, generates significant amounts of highly concentrated wastewater. Because of rising discharge regulations and water conservation efforts, more LFP cathode production plants are required to achieve zero liquid discharge (ZLD). The PX U series has been implemented in over 10 ZLD projects to lower the energy consumption of treating wastewater for reuse. The solid waste byproducts were then sold as ammonium sulfate fertilizer, helping to offset costs.

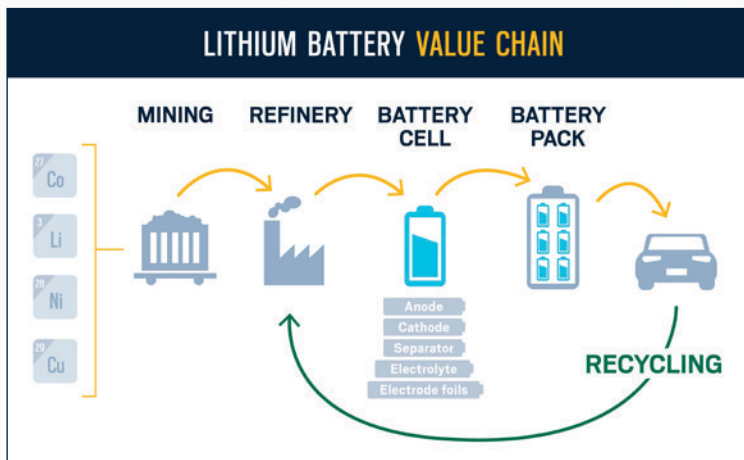
Benefits

- Implement minimal and zero liquid discharge
- Reduce energy consumption and associated emissions for water reuse
- Reuse waste byproduct



APPLICATION OF FULL SUITE OF PX DEVICES (CASE STUDY)

Energy Recovery worked with a lithium iron phosphate (LFP) cathode manufacturing facility in the Hubei province of China to increase energy efficiency and waste valorization. A combination of PX 140 and PX U40 implemented after pretreatment and LPRO successfully reduced the flow rate by 90% before the thermal process and reduced the operating costs of ZLD by over 50%, saving the facility approximately \$186,000 USD annually.*



APPLICATION OF PX (CASE STUDY)

In the Jiangxi Province in China, a flexible two-stage reverse osmosis process was used to achieve minimal liquid discharge for a battery recycling plant to recover not only lithium but also nickel and cobalt. The goal was to remove 95% of the water to maximize resource recovery with membranes and pressure exchangers. In each RO step, a PX recovered wasted pressure energy to reduce the feed flow through the high-pressure pump.

Lithium Battery Recycling

Reverse osmosis with PX technology can be utilized in various lithium-ion battery recycling processes to recover valuable resources such as lithium, cobalt, and nickel. Depending on the type of feed in the RO system, the PX can reduce energy use by up to 50%. Although a relatively new development in Europe and North America, China is already using RO systems for battery recycling to separate lithium salts, nickel sulfate, and cobalt sulfate with membranes prior to further processing.

Benefits

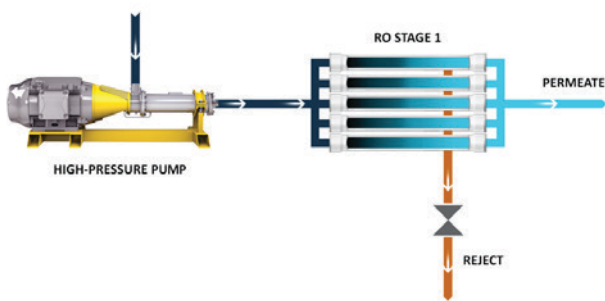
- Reduce the energy use of downstream evaporation for MLD with membranes
- Provide high-purity water for reuse
- Capture and retain valuable resources

How the PX Pressure Exchanger Works

Engineered with only one moving part made of highly durable and corrosion-resistant ceramic, the PX® Pressure Exchanger® is our flagship product that transfers pressure energy from high-pressure reject brine to low-pressure feedwater, thereby lowering the stream volume through the high-pressure pump to recover wasted energy.

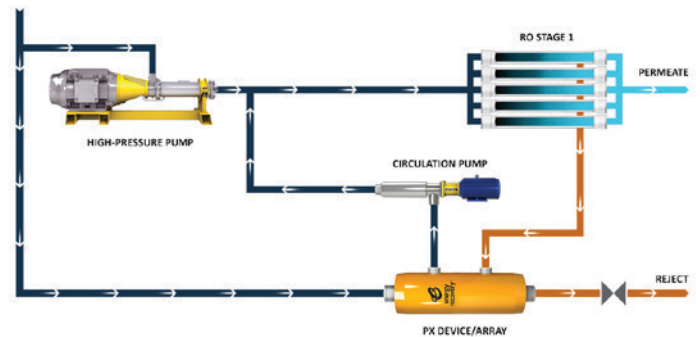
In lithium applications, the PX reduces the energy consumption of reverse osmosis to separate lithium from brine, recover resources in battery recycling plants, or treat wastewater from lithium battery manufacturing plants. The entire PX product family is currently installed and operating in lithium brine mining, LFP cathode manufacturing, and battery recycling applications to lower operational energy costs.

WITHOUT THE PX PRESSURE EXCHANGER



PROBLEM: Without the PX, an estimated 60% of energy in the reverse osmosis system could be wasted.

WITH THE PX PRESSURE EXCHANGER



SOLUTION: By utilizing the PX, plants can expect to save up to 60% of energy that would otherwise be wasted.

PX technology can be configured for single or multi-stage RO systems

BENEFITS OF THE PX PRESSURE EXCHANGER*

- **Highly Efficient:** Peak efficiency of 98% and energy reduction of up to 60%
- **Reliable:** Industry-leading 25-year design life and 99.8% uptime
- **Flexible:** Compatible with new or existing plants over a wide pressure range up to 120 bar (1,740 psi)
- **Low Mixing:** Low volumetric mixing

Trusted for Over 30 Years

For over 30 years, Energy Recovery has perfected its gold-standard PX Pressure Exchanger. Proven in the desalination industry, the technology is trusted to increase operational efficiency for RO and nanofiltration systems. We have continued to provide a positive environmental impact on our customers worldwide, with over 35,000 PX units operating globally. Energy Recovery's engineering and technical development team offers system design expertise to optimize the energy use of brine concentration processes to recover lithium or related resources.

