VEOLIA

Lithium Processing and Battery Recycling

Qualifications & Experience

WATER TECHNOLOGIES

CONTENTS

VEOLIA WATER TECHNOLOGIES
BY THE NUMBERS

€ 1.6B
In Revenue (2022)

6,643
Employees Worldwide

800
Innovation Experts Worldwide

350+
Proprietary Technologies

1,641
Technology Patents

The Veolia Group

With nearly 220,000 employees worldwide, Veolia Group designs and provides water, waste and energy management solutions which contribute to the sustainable development of communities and industries. Veolia (NYSE: VE and Paris Euronext: VIE) has been creating integrated environmental solutions for industries and municipalities since 1853. Veolia recorded annual revenues of more than €42.885 billion in 2022.

Veolia Water Technologies

Veolia Water Technologies, a subsidiary of the Veolia group, is the leading specialist in water and wastewater treatment. Our teams design and deliver drinking water or wastewater treatment plants as well as smaller standardized water treatment equipment for industrial or municipal customers. VWT also offers a range of services to cover all water treatment plant management needs.

Drawing upon Veolia's 350 proprietary technologies, our process experts custom design and engineer the best solution for each application. For existing facilities and aftermarket needs, we also provide field service engineers and technicians to keep your water treatment systems operating at maximum efficiency. We provide solutions to improve your processes, ensure regulatory compliance, minimize water consumption through recycle and reuse, and identify opportunities for maximizing resources through water and byproduct recovery.

We identify opportunities for recycling and reuse of resources, product recovery and energy production as part of our water treatment processes. Through in-depth research and development, Veolia is committed to providing sustainable technologies and value-added engineering to its customers.

Veolia Water Technologies helps lithium producers overcome challenges by developing and optimizing the production process to reliably meet production targets.

Veolia's Expertise Includes:

- Battery Materials Purification and Crystallization (LiOH, Li_2CO_3, LiCl, $NiSO_4$, $CoSO_4$, $MnSO_4$)
- By-product Recovery from Lithium Processing (KCl, Na_2SO_4, NaCl, K_2SO_4, H_3BO_3)
- Lithium Brine Pretreatment and Concentration (Metals Removal, Softening, IX, RO, NF, Evaporation)
- Battery Recycle and Materials Recovery
- ZLD Waste Treatment
- Water Recovery

The Global Leader in Lithium Processing

As a worldwide leader in supply of brine treatment technologies and chemical processing systems, Veolia can help producers and recyclers meet the technical challenges associated with the rising demand for efficient production or recycle of high-purity lithium and battery material salts for advanced electric battery manufacturing.

A Preferred Partner for Project Development

Veolia is a reliable partner in the development of each unique project. Combining expert process development and validation with early scope development provides the client with options for achieving both optimum system performance and key business objectives.

Resources such as research and testing facilities, in-house multi-disciplined engineering teams, and a single-point project management model allow a comprehensive overview of the project for the client. This flexible approach makes Veolia a preferred partner for FEED or phased engineering contracts for highly complex projects.

Our Process For Executing Projects

1. R&D, FEED Studies and Pilot Testing
2. Technology Identification and Process Design
3. Engineering & Design
4. Equipment Supply & Project Execution
5. Start-Up, Commissioning & Performance Testing

Research & Development

Veolia's 5,000 m² Research and Development Center is crucial for development of challenging process designs for HPD® Evaporation and Crystallization technologies. The facility is home to a wide variety of tools used for investigation of new process designs, testing to support customer projects, and development of new technologies. It is the foundation for design evaluation, feasibility, and process validation as well as improvement and economizing overall system designs.

The analytical, bench-scale, and pilot-scale testing capabilities, with an extensive catalog of data, allows advancement of first-of-a-kind innovations. This is especially important to design processes for achieving the purity requirements in evolving lithium applications and purity requirements.

Rigorous testing provides the confidence that the commercial system will perform as designed.

HPD® Evaporation & Crystallization

Through its global sales network and local field service support, Veolia's world-class HPD® evaporation and crystallization systems have been the technologies producers rely on to extract the most high-purity lithium carbonate, lithium hydroxide and other cathode material salts while removing persistent impurities and recovering valuable chemical compounds containing potassium, sodium, calcium, and magnesium.

Evaporation Technologies:

- Thermal Vapor Recompression
- Mechanical Vapor Recompression
- Multiple Effect
- Long-tube Vertical (Rising-film and Falling-film)
- Forced Circulation
- Multi-stage Flash
- Horizontal Spray Film

Crystallization Technologies:

- Draft Tube Baffle (PIC)
- Surface Cooling
- Forced Circulation
- Growth (Oslo type) Crystallizer
- Reactive
- Adiabatic Flash

Integrated Auxillary Systems:

- Centrifuging
- Filtration
- Drying
- Membrane
- Ion Exchange
- Reaction / Clarification

KEY FACTS

85+
Years in Operation

>1,000
Evaporation & Crystallization References Worldwide

Whittier Filtration & Separation

Veolia Water Technologies combines innovative technology with industry experience to provide economical and effective filtration and separation technologies. Our wide range of technological solutions is supported by a dedicated staff with an unmatched reputation for the highest quality of customer service.

Ion Exchange

Lithium Brine Impurity Removal System

This ion exchange (IX) technology by Veolia is a speciality IX system that removes impurities from the lithium brine prior to evaporation and crystallization of the lithium solution.

How does it work?

As the brine flows through the ion exchange column, impurities present in the brine are exchanged with other ions present on the resin. The exchange process is driven by the difference in the affinity of the resin for impurity ions over other ions. Unwanted ions, such as magnesium, calcium, and boron will be removed during this process.

System Information:

- Specialty IX system designed for treatment of lithium brine
- Configuration can include either Lead-Lag-Regen or Lead-Lag-Lag-Regen
- High dissolved solids streams
- Heavy duty construction
- Chelating resins for concentrated brine, HCl and NaOH regenerated

Auto-Jet®

Pressure Leaf Filtration for Battery Recycling

The Auto-Jet precoat filtration technology can be utilized in the purification step of the recovery of precious elements inside lithium-ion batteries.

System Information

- Fully-automated self-cleaning pressure leaf filter equipped with auto-lock door, leaves rotate during cleaning
- Wet-cake or dry-cake discharge
- 50-2000 ft^2 filter area
- Materials: CS or any alloy construction and lining when needed
- Inlet solids: typically 100-300 mg/L
- Outlet particle size: typically 1-micron (0.5 micron possible)

Auto-Jet

Ion Exchange

Water & Wastewater Treatment

Veolia's more than 350 patented technologies provide innovative solutions to help the lithium industry succeed in meeting strict regulatory requirements and optimize water usage throughout the facility.

Actiflo® High-Rate Clarifier/Softener

Small-footprint technology in which water is flocculated with microsand and polymer to increase settling velocity for the removal of more than 99% of TSS

Multiflo® High-Rate Softener

Proprietary softening process that incorporates chemical precipitation with sludge thickening to produce an effluent with low concentrations of scale-formers and a highly concentrated sludge that can be easily dewatered

Hydrotech Drumfilters & Discfilters

Filtration technology that uses woven media panels to remove suspended solids > than 10 microns

Zero Liquid Discharge Systems

Advanced wastewater treatment technologies that aim to eliminate the discharge of liquid waste by recovering and reusing all water and producing solid waste

Reverse Osmosis (RO) Systems

Advanced membrane based water filtration systems engineered to create a high-quality permeate

TERION™

Single-skid RO-CEDI unit that combines single-pass reverse osmosis and continuous electrodeionization

Sand, Multimedia, Carbon, and Cartridge Filters

Efficient equipment designed to remove particles, odors, and organics to improve intake water quality for use in utilities and manufacturing

Ion Exchange Systems

Flexible and automated water treatment systems used to soften, dealkalize, deionize, or demineralize water for utility or process applications

Toyotsu Lithium Corporation (2018)

JV with Allkem & Toyota Tsusho

Location: Japan

Challenge

Thanks to low-cost operations and strong demand from Japanese battery makers, lithium carbonate volumes have been steadily increasing since Toyota Tsusho and Allkem first produced lithium in 2015 at their brine-based Olaroz lithium facility in northern Argentina.

To support this growth, the joint venture made one of the biggest investment decisions to raise output in the South American lithium market, and the new Naraha hydroxide plant that processes this increased feedstock capacity is a first of its kind in Japan.

Key Project Drivers

> The need to achieve 10,000 tons per year of purified battery-grade lithium hydroxide

> Support the growing need for electrical storage for electrical devices such as electric vehicles

Solution

Driven by their joint success in supporting the rapid evolution and adoption of electric mobility, Toyota Tsusho Corporation, a global trading company in the Toyota Group, and Allkem, an Australia-based industrial chemicals company, along with their joint venture Toyotsu Lithium Corporation awarded Veolia a comprehensive engineering, procurement, and construction (EPC) contract to build a new plant in Japan. The Naraha facility is designed to convert 9,500 tonnes per annum (tpa) of technical-grade lithium carbonate into 10,000 tons per annum of purified, battery-grade lithium hydroxide.

Veolia Water Technologies provided a chemical processing plant featuring HPD® evaporation and crystallization technologies designed to convert lithium carbonate into lithium hydroxide employed in the manufacturing of batteries that power electric vehicle.

To demonstrate the feasibility of the process design, Veolia successfully conducted laboratory testing and simulated key unit operations including clarification, ion exchange purification, evaporation, crystallization, and precipitation at its Phillip J. Stewart Technology Center in Plainfield, IL (USA).

The results obtained from this work confirmed the design parameters, reduced the technical risks and boosted the project viability resulting in the joint venture's decision to allocate the funds for the investment, which was also supported by a grant from the Japanese government.

Key Project Details

LITHIUM
Industry

10,000
tons per year of battery-grade lithium hydroxide

R&D
state-of-the-art facility to demonstrate feasibility

Confidential Lithium Producer (2020)

Location: APAC

Challenge

As the global demand for cleaner, battery-based energy storage systems and electric vehicles is on the rise, so too is the demand for battery quality lithium hydroxide.

When in full production, the client will produce enough lithium hydroxide to enable approximately one million electric vehicles to replace regular vehicles on the road each year.

Key Project Drivers

> Ability to achieve 50,000 tons per year of purifiied battery-grade lithium hydroxide

> Support the need for additional eco-friendly vehicles to replace fossil-fuel driven vehicles

Solution

Veolia partnered with the client to develop a state-of-the-art manufacturing process that takes spodumene ore as a feedstock. After extensive testing and piloting, Veolia developed a specialized process using several proprietary HPD® evaporation and crystallization technologies to maximize lithium recovery and produce market-leading battery lithium hydroxide monohydrate, a critical material used in the production of electric vehicle batteries.

The facility will feature several HPD® evaporation and crystallization technology packages and produce up to 50,000 tons of high-purity lithium hydroxide. The project is expected to be one of the world's largest manufacturing sites of its kind.

Included in the technology supplied by Veolia is a multiple step processing facility consisting of a Glauber's Salt Crystallization system for sulfate removal including a byproduct sodium sulfate crystallizer for product sale, followed by a two stage MVR Lithium Hydroxide Crystallizer to make battery-grade lithium hydroxide.

In addition to the main production process, Veolia will install several other technologies at the site to improve sustainability and support the client in achieving the efficient use of natural resources for this specific project, including specialty Ion Exchange technology for brine purification.

Key Project Details

LITHIUM
Industry

50,000
tons per year of lithium hydroxide

1,000,000
gas-powered cars replaced by electric vehicles

Confidential Lithium Refinery (2022)

Location: APAC

Challenge

The client was in need of a demineralized water treatment system and wastewater treatment at their lithium refinery in order to process 50,000 tons per year of lithium hydroxide.

Key Project Drivers

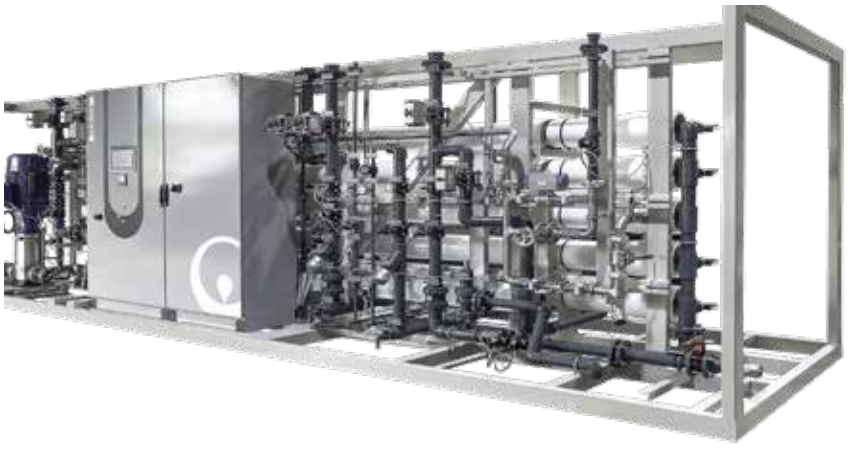
- **The need to partner with a water treatment supplier that has proven experience with demineralized water production and industrial wastewater treatment projects**

Solution

The client entrusted Veolia Water Technologies for the design and supply of the two packages to support its lithium refinery production.

The first package included a demineralized water plant to produce 19m³/h of high purity demin water (≥15MΩ.cm) utilizing Veolia's TERION™ (RO+CEDI) technology for use within the lithium refinery.

Secondly, Veolia supplied a dilute wastewater treatment plant to treat 12m³/h of combined spillage and run off wastewater and dilute wastewater streams. The treated water will be recycled as process water for use within the lithium refinery.



Key Project Details

LITHIUM
Industry

>19 m³/h
demineralized water

>12 m³/h
dillute wastewater treatment

Li-Cycle (2021)

Location: United States

Challenge

As the global demand for cleaner, battery-based energy storage systems and electric vehicles is on the rise, so too is the need for sustainable solutions to recover the valuable materials inside them.

Li-Cycle was in need of partnering with a technology provider at their Rochester, NY facility to help recover critical materials from lithium-ion batteries so they can reintroduce them back into the supply chain.

Key Project Drivers

> Increased demand for spent battery material recycling

> Support the growing need for electrical storage for electrical devices such as electric vehicles

> Resource recovery initiative to produce high-quality sodium sulfate as a by-product

Solution

Veolia's HPD® crystallization technology is key in a final stage of the battery recycling process as it allows to optimize the creation of nickel sulfate and cobalt sulfate from lithium-ion batteries, and transform them into high-purity raw materials, ready to be used in new batteries.

Included in the technology package supplied by Veolia is a cobalt sulfate crystallizer, a nickel sulfate crystallizer and a sodium sulfate system. Nickel and cobalt will be recovered and recycled from the scrap lithium batteries and Li-Cycle will utilize the crystallizers to create approximately 7,500 tons per year of nickel sulfate and 48,000 tons per year of cobalt sulfate that can then be resold to battery manufacturers – ultimately giving the original battery materials a new life.

The sodium sulfate system, which includes an evaporator, a Glauber's salt crystallizer and an anhydrous sodium sulfate crystallizer, will also recover sodium sulfate from the process to create a by-product that can be sold as well.

Results

Li-Cycle is able to help give life back to more than 225,000 electric vehicle batteries per year by utilizing HPD® crystallization technology to process recycled lithium battery materials.

Key Project Details

BATTERY RECYLING
Industry

>7,500
tons per year of nickel sulfate

>48,000
tons per year of cobalt sulfate

Confidential Battery Recycler (2022)

Location: United States

Challenge

The electronics market for cell phones, laptops, power tools, smartwatches, data centers and countless other battery-powered devices is already creating massive amounts of scrap products. With lifetimes much shorter than electric vehicle batteries, these devices find themselves in the waste stream far sooner. This creates a challenging environmental problem. As global demand for electronics continues to grow, so is the need to provide sustainable solutions to recycle and recover the valuable materials inside them.

Key Project Drivers

- Need for a technology with minimal footprint due to space constraints
- Cost-effective solution with proven experience

Solution

Veolia Water Technologies has partnered with this confiential client in the United States to supply its Whittier Auto-Jet® technology for their lithium-ion battery recycling plant.

This facility will recycle batteries, electronics, and end-of-life products with environmentally-sound processing and refining technologies to produce key elements for circular supply chains. Included in the technology package supplied by Veolia are 10 Auto-Jet pressure leaf filters that will form part of the purification step in the recovery of precious elements inside these lithium-ion batteries.

Key Project Details

BATTERY RECYLING

Industry

Resourcing the world

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