

# Lithium processing technology

## Complete solutions that provide powerful returns



**FLS**

# Maximising your lithium production

Lithium forecasts indicate demand will more than triple over the next decade. With the newest technology, backed by years of experience in brine and spodumene extraction methods, we are a full solutions partner for major lithium processing operations.

## The FLS lithium processing advantage

Whether you need separate pieces of equipment, islands or total process flow solutions, we provide the technology and service support to reliably increase your productivity and efficiency, while reducing your operating costs.

The two primary production methods for lithium – brine evaporation and hard rock (e.g. spodumene) processing – come with their own unique set of challenges. We have more than 20 years of experience in providing cutting-edge technologies that cover both approaches for lithium production. Our capabilities include:

- Hard rock concentrators
- Hard rock concentrate refinery facilities
- Brine processing facilities

## Key benefits

- More than 20 years of experience in providing market-leading lithium processing solutions
- Broad equipment offering and customisable solutions
- Full lifecycle partnership
- Cutting-edge technology
- Additional technologies not offered by other providers
- Bench and pilot testing facilities
- Superior pyro processing test facilities worldwide
- Focus on safety and providing the ideal productive solution for each customer

# Market-leading technologies with a powerful partner

We understand your challenges. With FLS as your partner, you benefit from our technology and full support, developed with your entire lithium processing operation in mind – now and into the future.

## Lithium processing technologies

A key issue for the spodumene miners is how to reduce production costs. For brine miners, the question is how to produce more volumes more quickly, with the least environmental impact.

We have pioneered the global lithium processing industry for more than 20 years. With an established record of product and technology innovation, we are constantly pursuing innovation to meet the challenges you face, no matter where you are in the world.

## We are your lifecycle partner

Our equipment is backed with world-class support throughout its lifecycle. Beginning with design, through delivery, installation, commissioning and advisory services, you can rest assured that we are just a phone call away, providing site management, process specialist support, first-time spares and more as we help you take care of your investment. From spare parts, to audits, repairs and maintenance support, our experts are always available to address the needs of your plant.



# A complete solution for lithium brine conversion

At FLSmidth, we believe business is easier when you can find all the most advanced solutions in one place. Putting that philosophy to practice, our full lithium brine conversion solution will help improve your performance, drive down your costs, and reduce the environmental impact of your operations.

## Lithium brine conversion

The extraction of lithium from brines comprises the pumping of salt-rich waters to the surface and into a series of evaporation ponds, where solar evaporation takes place over several months. Once the lithium chloride in the ponds reaches its optimum concentration, it is pumped to a recovery plant where extraction and filtering remove any unwanted minerals. Sodium carbonate treatment converts the lithium chloride to lithium carbonate, which is then filtered and dried. While startup costs can be high for lithium brine conversion and the process is somewhat slow, operational costs for this process are typically low.

## Our advanced technology – MaxR™ impurity removal

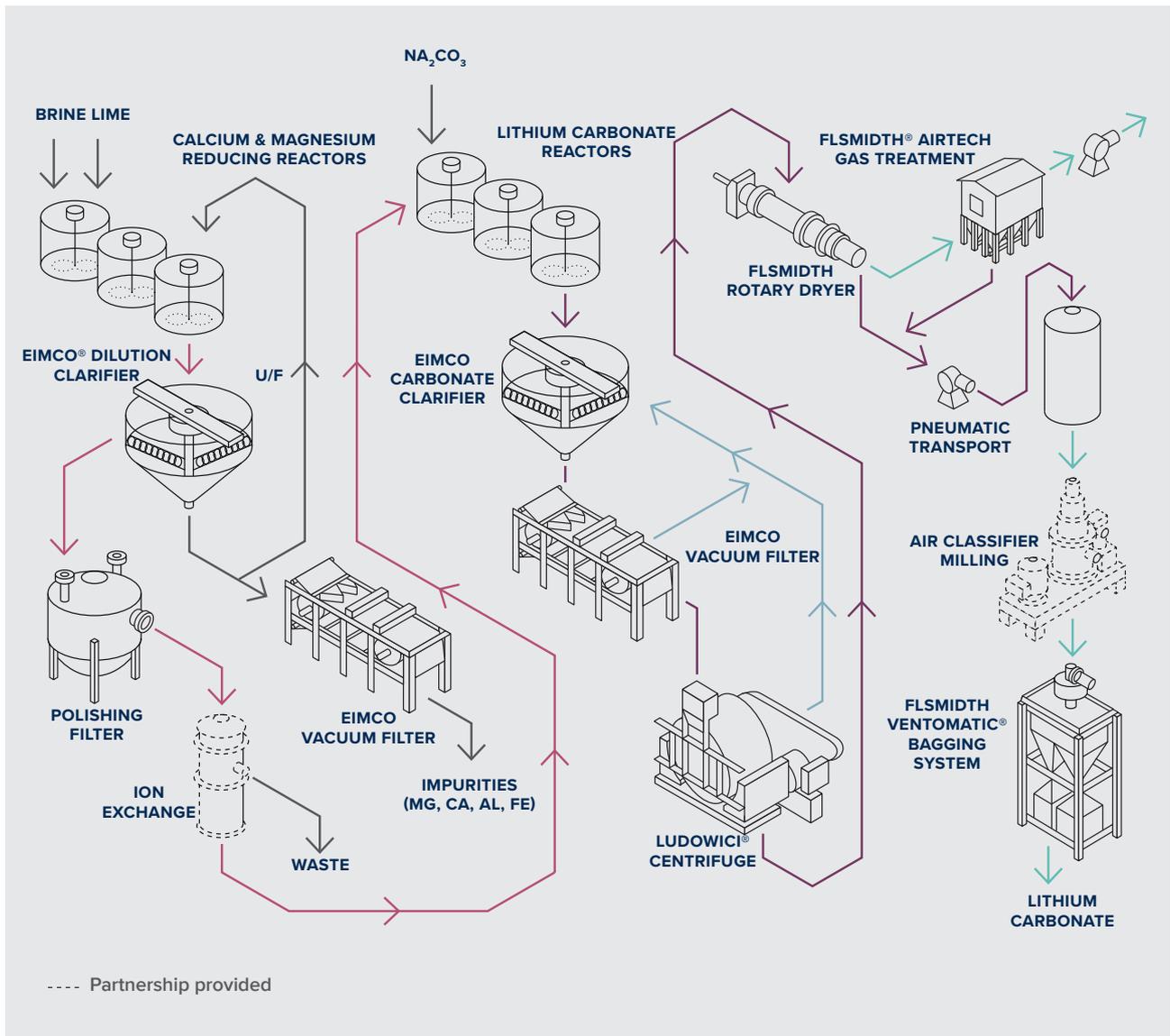
Impurity removal from the solar brine is a critical step in the process flowsheet for production of battery-grade lithium. Our MaxR™ technology provides the most advanced method in the industry, combining precipitation reactors with solid-liquid separation, which allows the seeding and particle growth of precipitates. This process enhances separation, as it also minimises reagent consumption and costs.



MaxR impurity removal technology package

# Brine flowsheet

We offer everything you might need for your lithium brine conversion operation – from cutting-edge equipment, to islands, to total process flow solutions.



# A complete solution for lithium spodumene concentration

In developing our lithium spodumene concentration solutions, we draw upon decades of experience in concentrator technology. As you choose your plant components, we will work to address your unique process challenges and enhance your operation's productivity.

## Spodumene concentration

Spodumene ores are typically consolidated from ore comprising 1–1.5% Li<sub>2</sub>O to a concentrate of about 6–6.5% Li<sub>2</sub>O. To achieve this, the ore passes through a typical concentrator-type plant, flowing from crushing and grinding, to gravity separation and DMS, to flotation, and then to the final dewatering of the concentrate. While spodumene concentration enjoys lower startup costs and quicker processing time to gain greater amounts of concentrates than brine conversion, the operational costs can be higher due to the cost of mining and energy consumption.

## REFLUX™ classifier

Our REFLUX™ Classifier (RC™) units employ the latest state-of-the-art fine particle technology (gravity-based separation), and offer significant advantages in capacity, adaptability and efficiency. REFLUX classifier technology is already well proven in a large number of operating spodumene concentrators.

## Flotation cells

The Dorr-Oliver® nextSTEP™ flotation mechanism is the most energy-efficient, technically advanced, forced-air flotation machine on the market. It has been specifically designed to maximise fine particle recovery. Dorr-Oliver flotation cells, in conjunction with the self-aspirated WEMCO® flotation cell, provide a mixed row flotation that delivers the highest recovery possible.



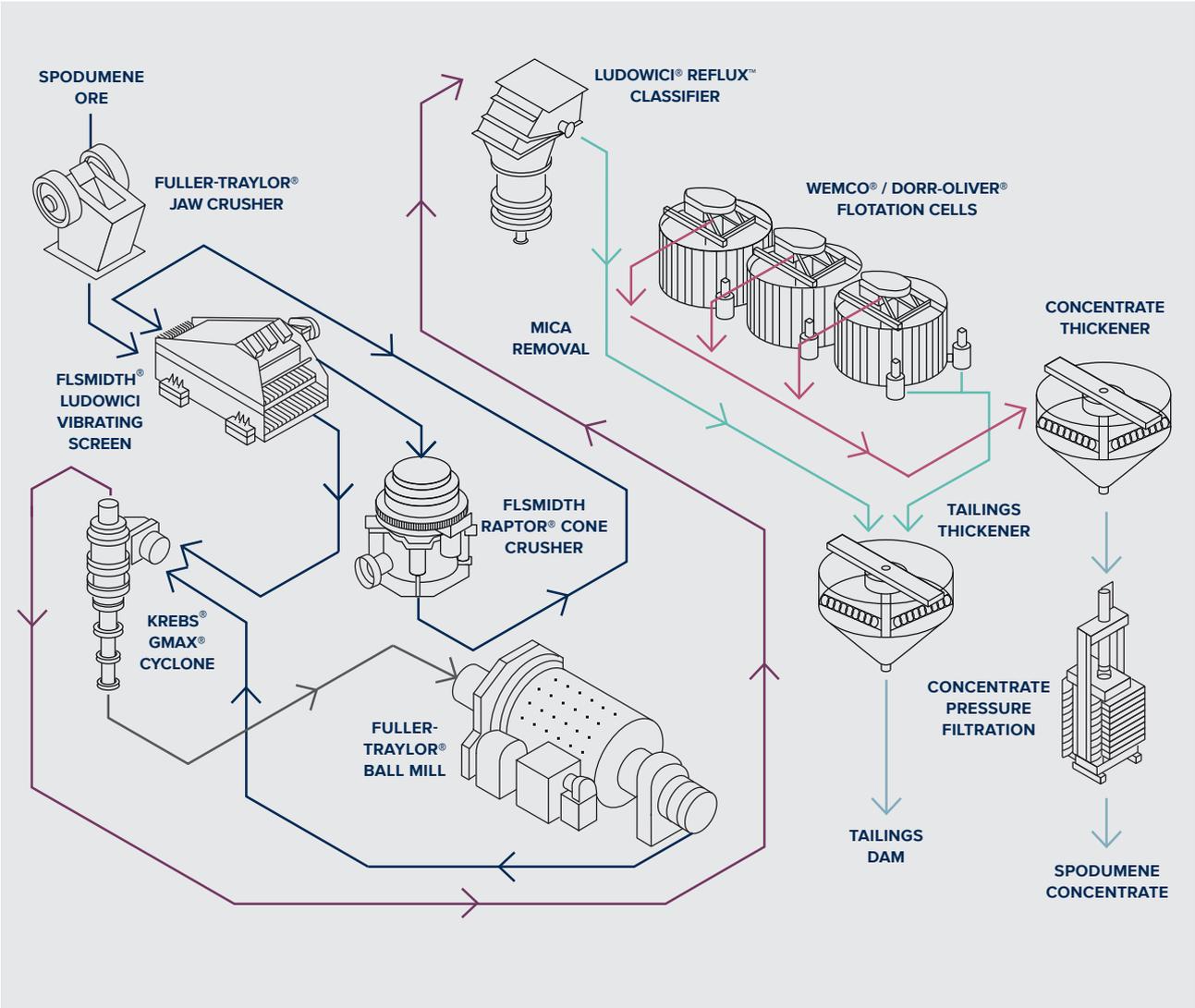
REFLUX classifier



Dorr-Oliver and WEMCO flotation cells

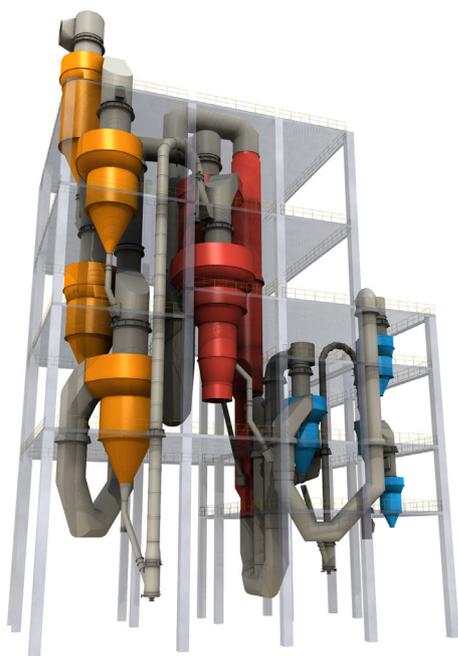
# Spodumene concentration flowsheet

We offer everything you might need for your lithium spodumene concentration – from advanced equipment, to islands, to total process flow solutions.

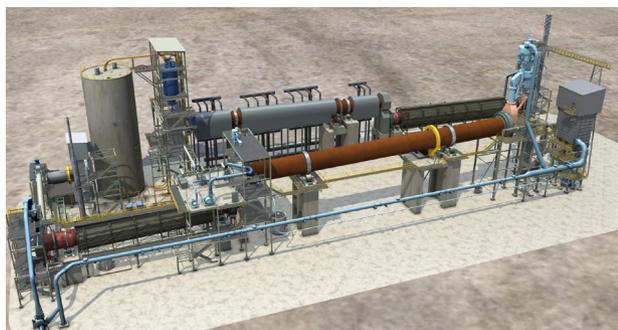


# A complete solution for lithium spodumene conversion and sulphating

By working closely with you, our experts provide productivity expertise; professional, in-depth equipment knowledge; and a comprehensive approach to improving your processes. Our goal is to help you significantly enhance your lithium processing operation's productivity.



**Gas suspension calciner (GSC) technology package**



**Rotary kiln calciner and acid roaster technology package**

## Spodumene conversion overview

In order to extract the valuable lithium from concentrate, it must first be converted from its natural alpha phase to beta phase via thermal processing. We offer multiple different calcining technologies including preheater kilns, suspension calciners, and fluid beds. Following its conversion and cooling, the beta spodumene may be milled using our ball mills and then transported to storage.

The beta spodumene is then dosed from storage to a mixer where concentrated sulfuric acid is mixed with it. Following mixing, the spodumene/acid mixture is introduced to our acid roaster, an indirect fired kiln, where a chemical reaction occurs producing water soluble lithium sulphate. The reacted material is then cooled prior to the next step in the process. A thickener-filter system separates waste from the resulting liquor, as precipitation removes magnesium and calcium from the amalgam. After adding sodium carbonate, the lithium liquor is crystallised, heated, filtered and dried to become lithium carbonate.

## FLS pyro-processing technologies

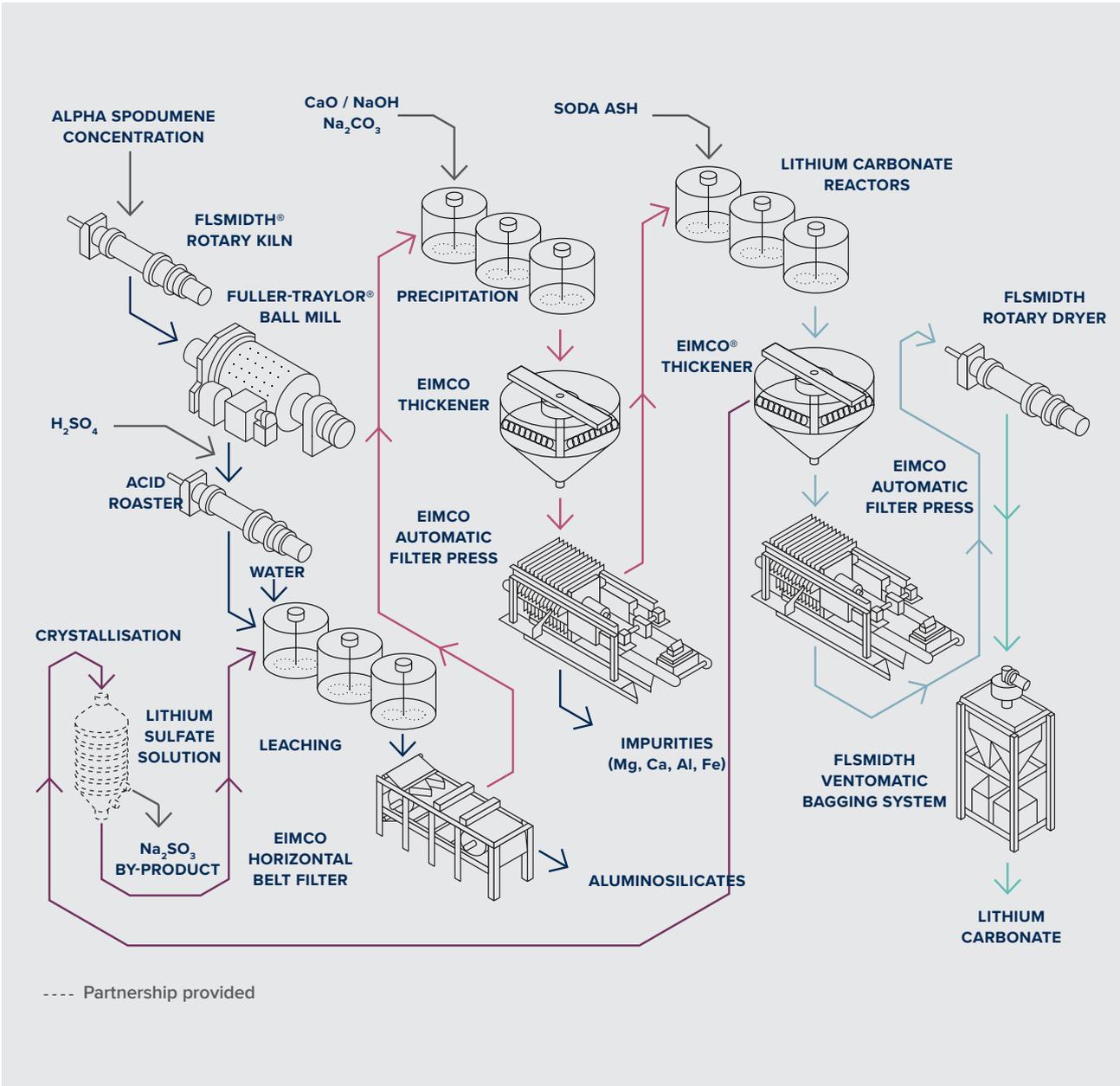
We have the largest range of lithium pyro-processing technologies on the market. Our equipment offering includes preheater rotary kiln calciners, flash suspension calciners, fluid beds, and acid roasters. Cutting-edge technology, such as preheater cyclones, significantly lowers your operating expenses by recovering waste heat from the kiln, compared to other technologies. Our systems are designed to fully recover all dust and convert it so there is no lithium loss.

## Solid-liquid technologies

With the longest record of accomplishment in the lithium processing industry, we are the world leader in advanced, market-leading thickener and filtration technologies, allowing us to meet your specific needs with optimised designs.

# Spodumene conversion flowsheet

We offer everything you might need for your lithium spodumene refining operation – from advanced equipment, to islands, to total process flow solutions.



# Testing and engineering

## Testing

We have a number of best-in-class testing centers for testing of brine and hard rock lithium sources.

### Pyro-Processing testing center capabilities:

- Batch rotary calciner
- Pilot rotary calciner with multi stage cyclone preheating
- Gas suspension flash calcination
- Indirect acid roasting
- Drying: flash dryer; rotary dryer; fluidised bed dryer
- Crushing/Milling
- Ball and vertical mills
- Classifier
- Crushers (jaw, roll, ABON®)
- Bond testing (ball, rod, abrasion, impact)
- Product analysis – specific gravity, total Li, and acid soluble Li
- Gaseous emissions analysis – required for permitting requirements

### Minerals Testing and Research Center

- Separation Technology Group
- Dawson Metallurgical Laboratory
- Analytical Laboratory
- Ore Characterisation and Process Mineralogy Laboratory

### Minerals Testing and Research Center capabilities include:

- Quantitative XRD Rietveld mineralogy
- SEM and optical microscopy
- Clay analysis
- AAS, ICP, ICP-MS, LECO and fire assay
- Grinding and classification
- Flotation concentration
- Thickening and filtration testing
- Leach testing
- Impurity removal precipitation testing
- Bench testing
- Pilot testing

## Engineering services

We provided the services required to engineer, procure and construct in virtually every major industrial market – for the mining, metals and minerals markets.

Our full-time engineering teams are trained in each discipline. These teams provide the best available solutions to your project using the most current resources, training and software.

- Process flowsheet development
- Plant layout
- Plant design

## Research and development for the future

We are committed to strong and on-going research and development which is focused on developing new and improved equipment and processing technologies that provide solutions to the ever-changing needs of our customers and the industries that we serve.

In addition to our own facilities, we foster and fund cooperative R&D efforts with global universities and contracted research organizations. Interaction with our customers sets the foundation of many of our R&D activities as seen by the numerous projects being conducted jointly with customers throughout the world.





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