

# **Overview of the Dry Process for Recycling of Lithium-ion Batteries Including Mechanical Treatment, Black Mass Drying, Electrolyte Recovery, Gas Treatment and Sorting**

**BARRY A. PERLMUTTER**

**Perlmutter & Idea Development (P&ID) LLC**

E-mail: [barry@perlmutterideadevelopment.com](mailto:barry@perlmutterideadevelopment.com)

Website: <https://perlmutterideadevelopment.com/>

Telephone: +1.704.996.0466

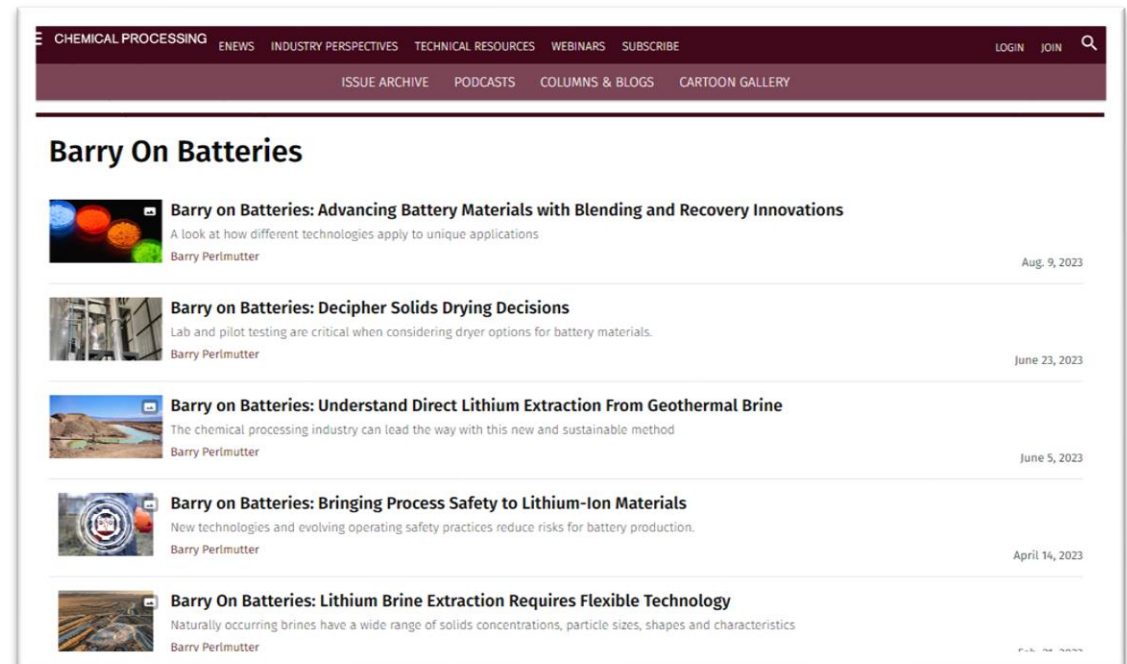
# Barry A. Perlmutter

## Overall Experience

- 40 years of international engineering and business marketing experience in the field of solid-liquid separation including filtration, centrifugation, drying, mixing & recycling
- Published & presented worldwide:
  - Author of [“Solid Liquid Filtration Handbook”](#) (Elsevier, 2015)
  - Editor of [“Integration & Optimization of Unit Operations”](#) (Elsevier, 2022)
- Professional skills focus on process solutions, innovation strategy, market expansion and business development.

## Lithium Market Expertise & Experience

- <https://perlmutterideadevelopment.com/lithium-battery-materials/>
- [Chemical Processing Magazine and Columnist for “Barry on Batteries”](#)
- [International Battery Seminar Conference Presentation](#)



The screenshot shows the website for 'Barry On Batteries', which is part of the 'CHEMICAL PROCESSING' publication. The navigation bar includes links for 'NEWS', 'INDUSTRY PERSPECTIVES', 'TECHNICAL RESOURCES', 'WEBINARS', 'SUBSCRIBE', 'ISSUE ARCHIVE', 'PODCASTS', 'COLUMNS & BLOGS', and 'CARTOON GALLERY'. The main content area is titled 'Barry On Batteries' and lists five recent articles:

- Barry on Batteries: Advancing Battery Materials with Blending and Recovery Innovations**  
A look at how different technologies apply to unique applications  
Barry Perlmutter  
Aug. 9, 2023
- Barry on Batteries: Decipher Solids Drying Decisions**  
Lab and pilot testing are critical when considering dryer options for battery materials.  
Barry Perlmutter  
June 23, 2023
- Barry on Batteries: Understand Direct Lithium Extraction From Geothermal Brine**  
The chemical processing industry can lead the way with this new and sustainable method  
Barry Perlmutter  
June 5, 2023
- Barry on Batteries: Bringing Process Safety to Lithium-Ion Materials**  
New technologies and evolving operating safety practices reduce risks for battery production.  
Barry Perlmutter  
April 14, 2023
- Barry On Batteries: Lithium Brine Extraction Requires Flexible Technology**  
Naturally occurring brines have a wide range of solids concentrations, particle sizes, shapes and characteristics  
Barry Perlmutter

# **Lithium-Ion Batteries Recycling Process For End-of-Life (EOL) Packs, Modules & Cells Production Scrap & Defective Battery Cells Small-Format Consumer Batteries**

- Overview of BHS-Sonthofen Technology Installations
- Deep discharging of batteries
- Dry (inerted) shredding/crushing/granulating
- Black mass vacuum drying with gas treatment, electrolyte recovery and dedusting
- Dust-tight classifying and sorting into different fractions

## Our business units – your industries

Innovative process solutions, technology and consulting services



### Process Technology

- » Chemicals
- » Pharmaceuticals
- » Food & feed
- » Oil & gas
- » Power generation
- » Metallurgy & batter materials



### Building Materials Machinery

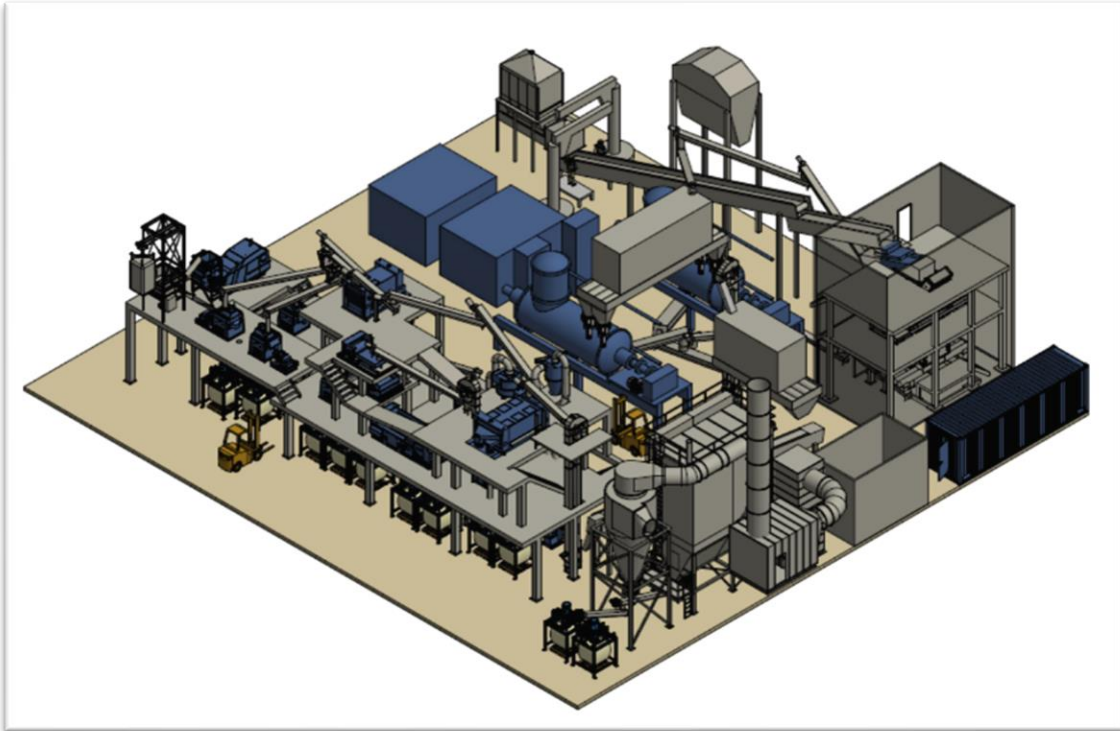
- » Concrete
- » Dry building materials
- » Road construction
- » Sand & gravel
- » Mining & minerals
- » Disposal



### Recycling Technology

- » Metal recovery
- » Industrial waste
- » Recycling various waste materials
- » Biomass

# BHS Technology Provider Recycling Solution



Client	Capacity	Description of Feed Stock
A	4 tons/hour	Production scrap, EV & Consumer batteries
B	50 kg/hour	Production scrap, EV batteries
C	4 tons/hour	Production scrap, EV batteries
D	2 tons/hour	Production scrap, EV batteries
E	2 x 2 tons/hour	Production scrap, EV & Consumer batteries
F	1 – 2 tons/hour	Consumer batteries
G	50 kg/hour	Consumer batteries
H	4 tons/hour	EV batteries, Consumer batteries
I	100 kg/Hour	EV batteries



## **BHS-Sonthofen Receives Order For BASF Battery Recycling Plant**

**BHS-Sonthofen is supplying BASF with a plant for the mechanical reprocessing of lithium-ion batteries into black mass. This marks the third large-scale plant for BHS, with the first one having operated successfully for over a year.**

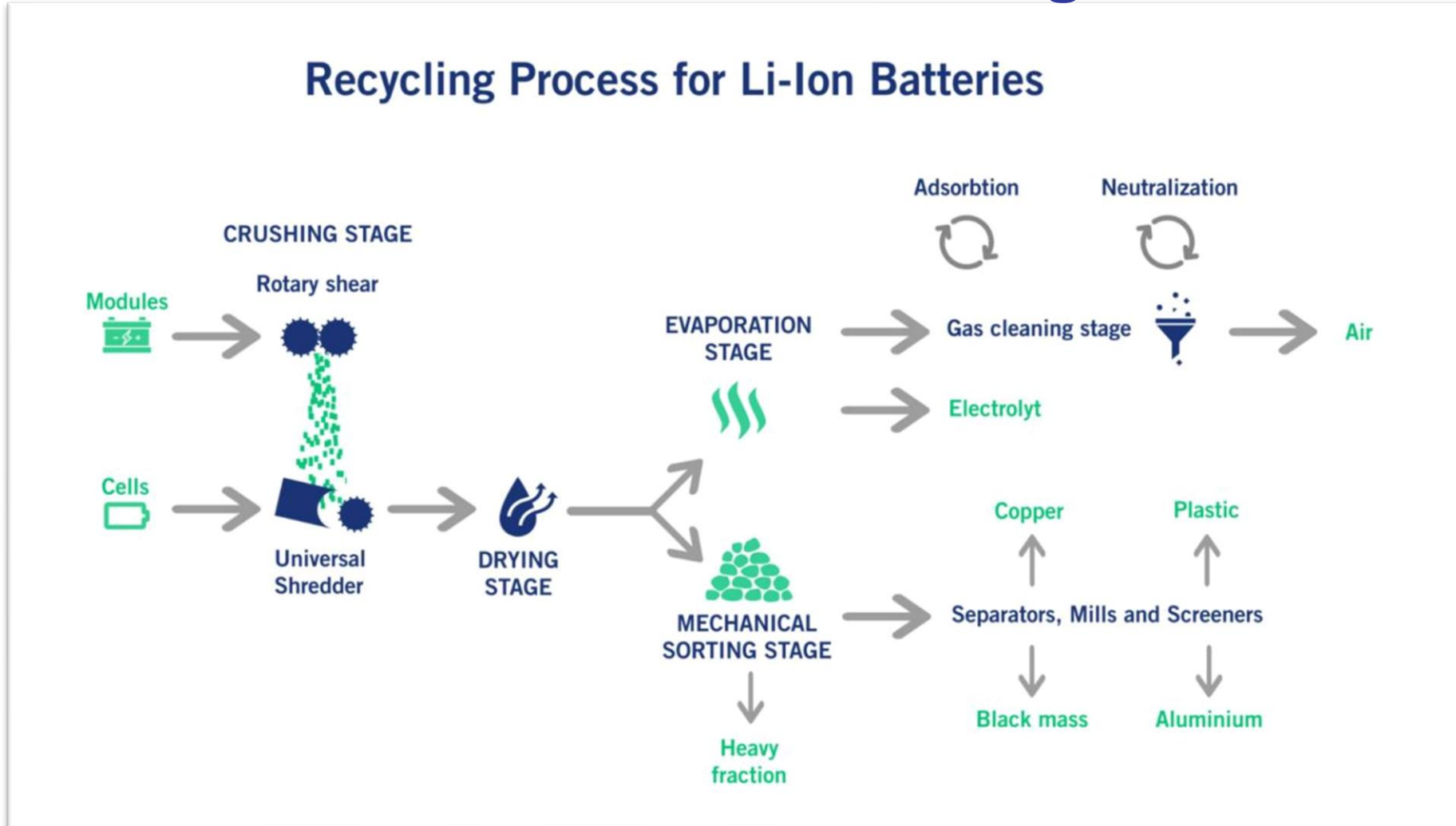
**<https://recyclinginside.com/battery-recycling/bhs-sonthofen-receives-order-for-basf-battery-recycling-plant/>**

## Northvolt Revolt Ett

All material may be used in  
both print and online media  
with reference to Northvolt

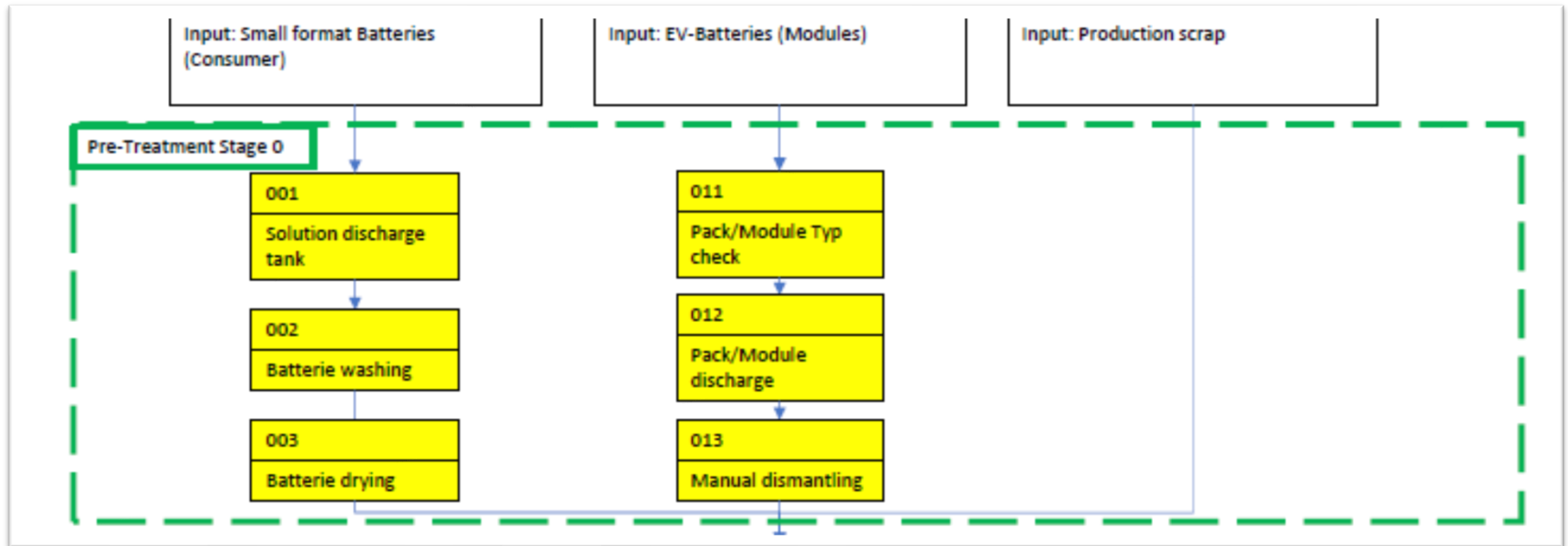


# BHS Technology Provider Recycling Solution Overall Process: Stages 1 - 4

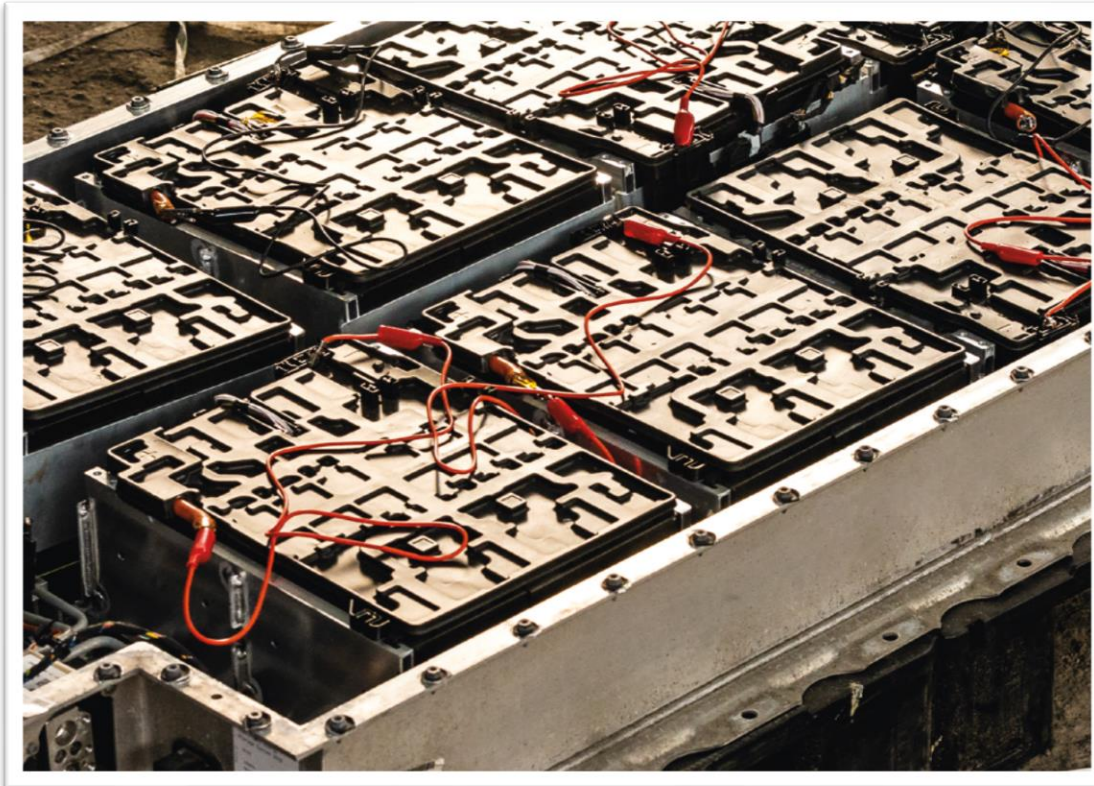




# BHS Technology Provider Recycling Solution Overall Process: Stage 0 for Discharging



# BHS Technology Provider Recycling Solution Overall Process: Stage 0 for Discharging



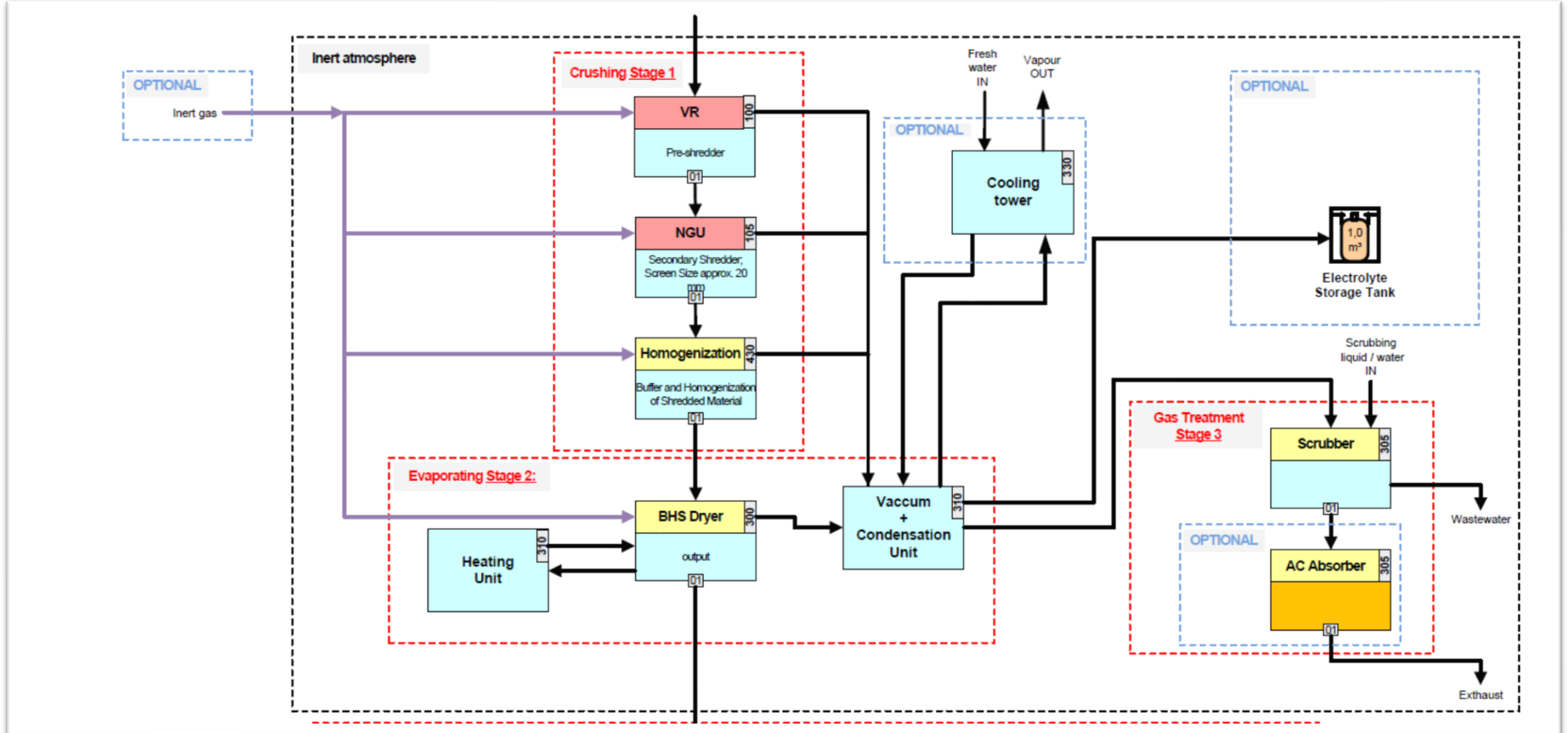
**Modules**



**Production Scrap**

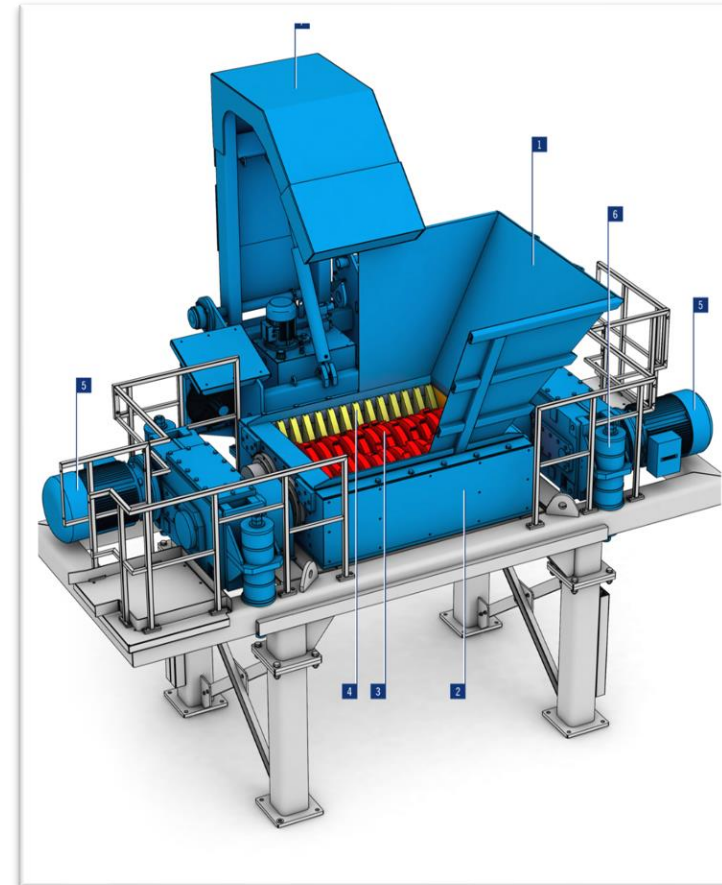
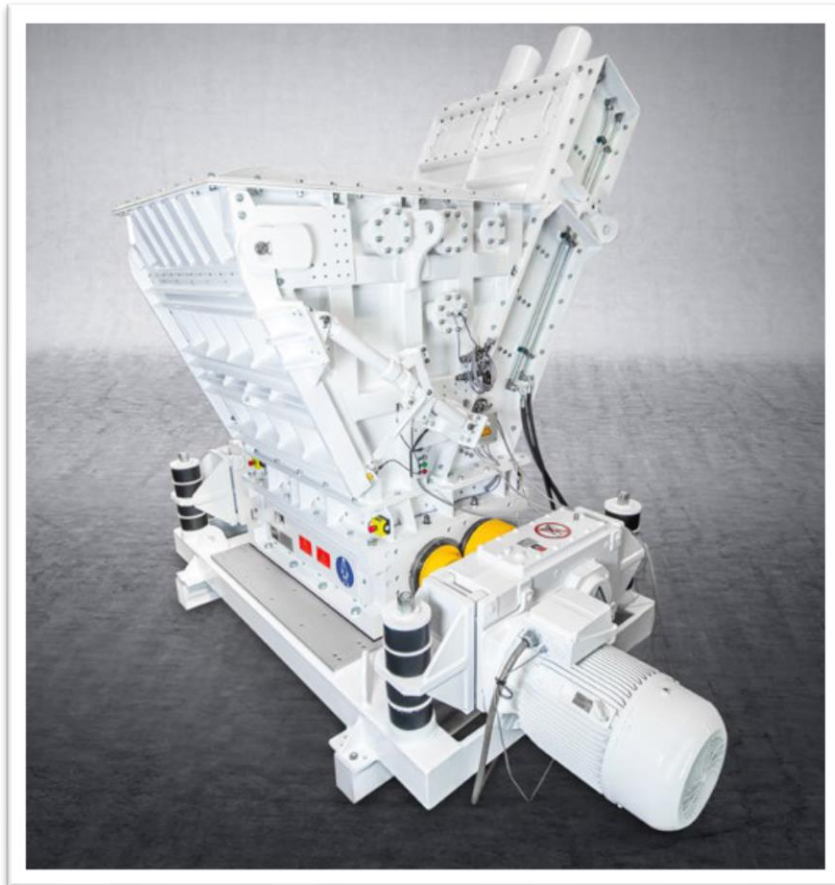
# BHS Recycling Solution

## Overall Process: Stages 1 – 3 Dry/Inerted





# BHS Rotary Shear VR Pre-Shredder Stage 1: Crushing



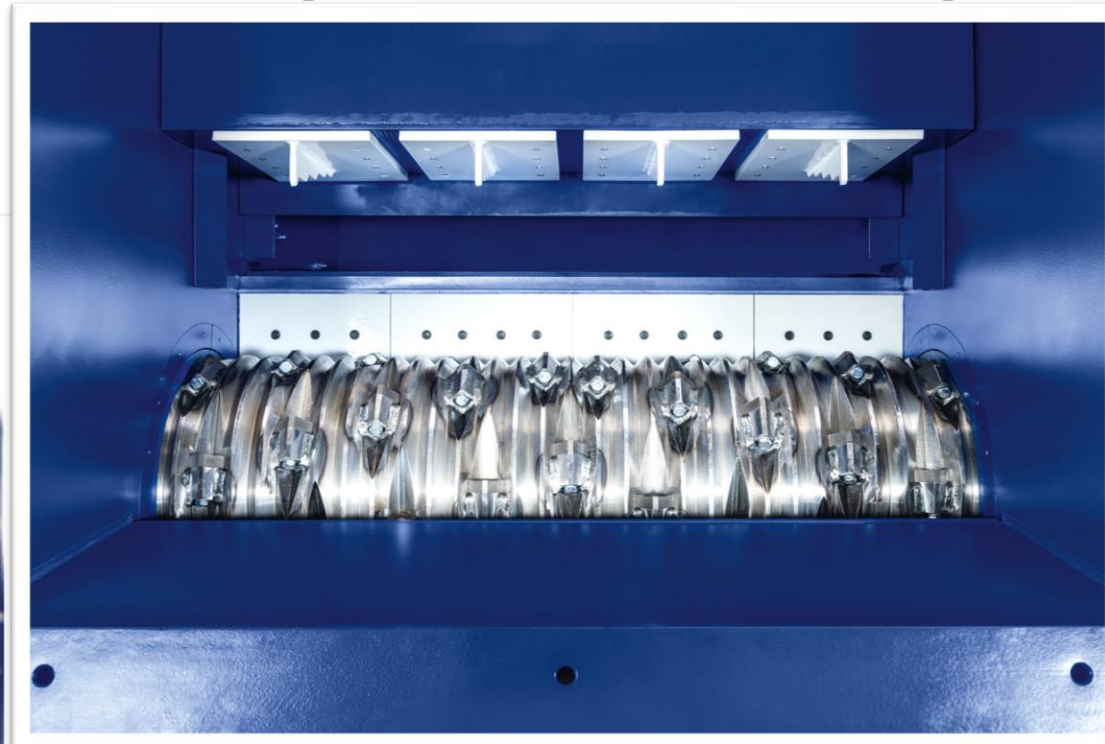
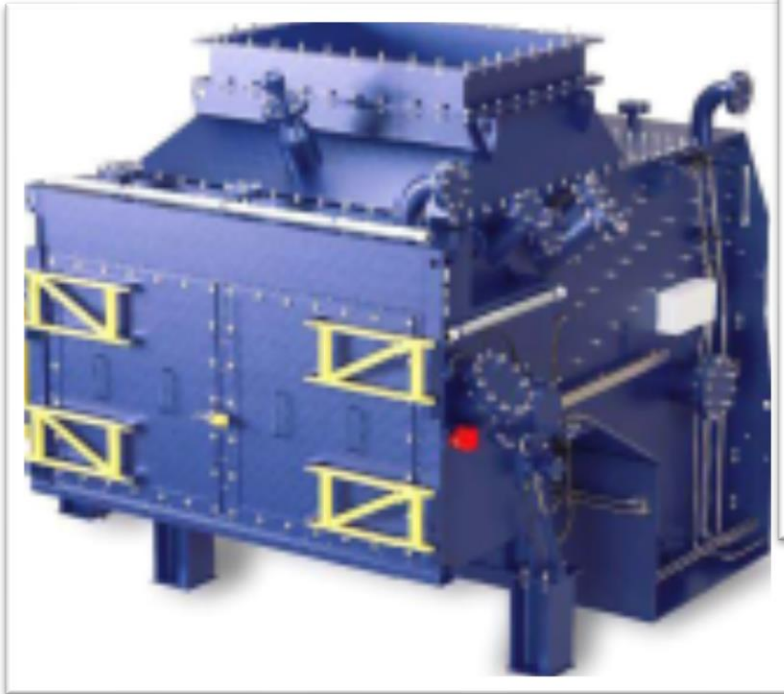


# BHS Rotary Shear VR Pre-Shredder Output



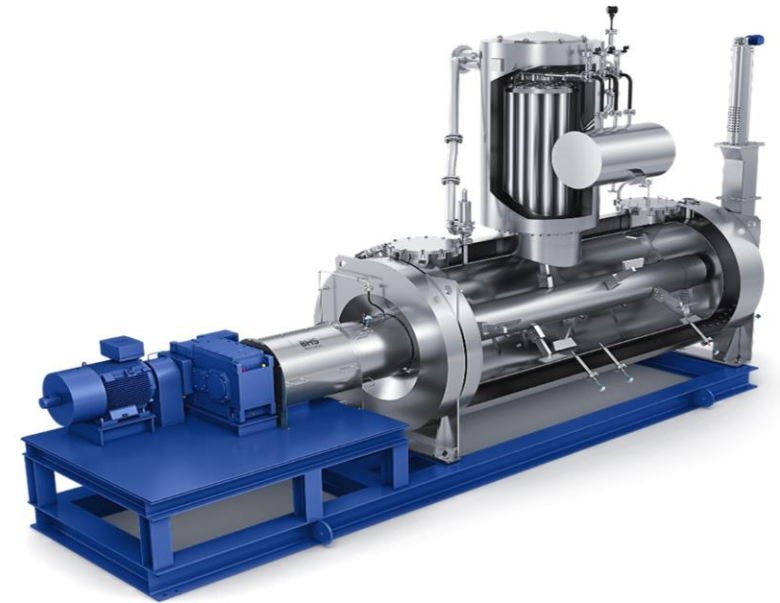
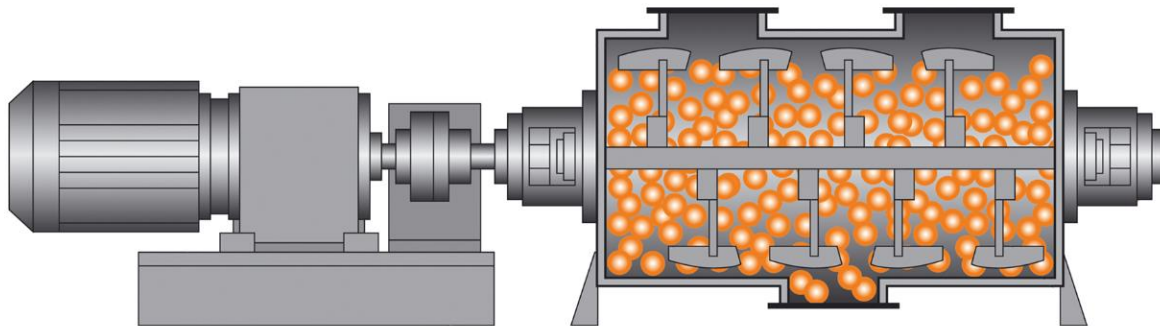
# BHS Universal NGU Granulator

## Stage 1: Crushing



# BHS Horizontal Evaporator Vacuum Dryer

## Stage 2/3: Vacuum Drying & Electrolyte Recovery





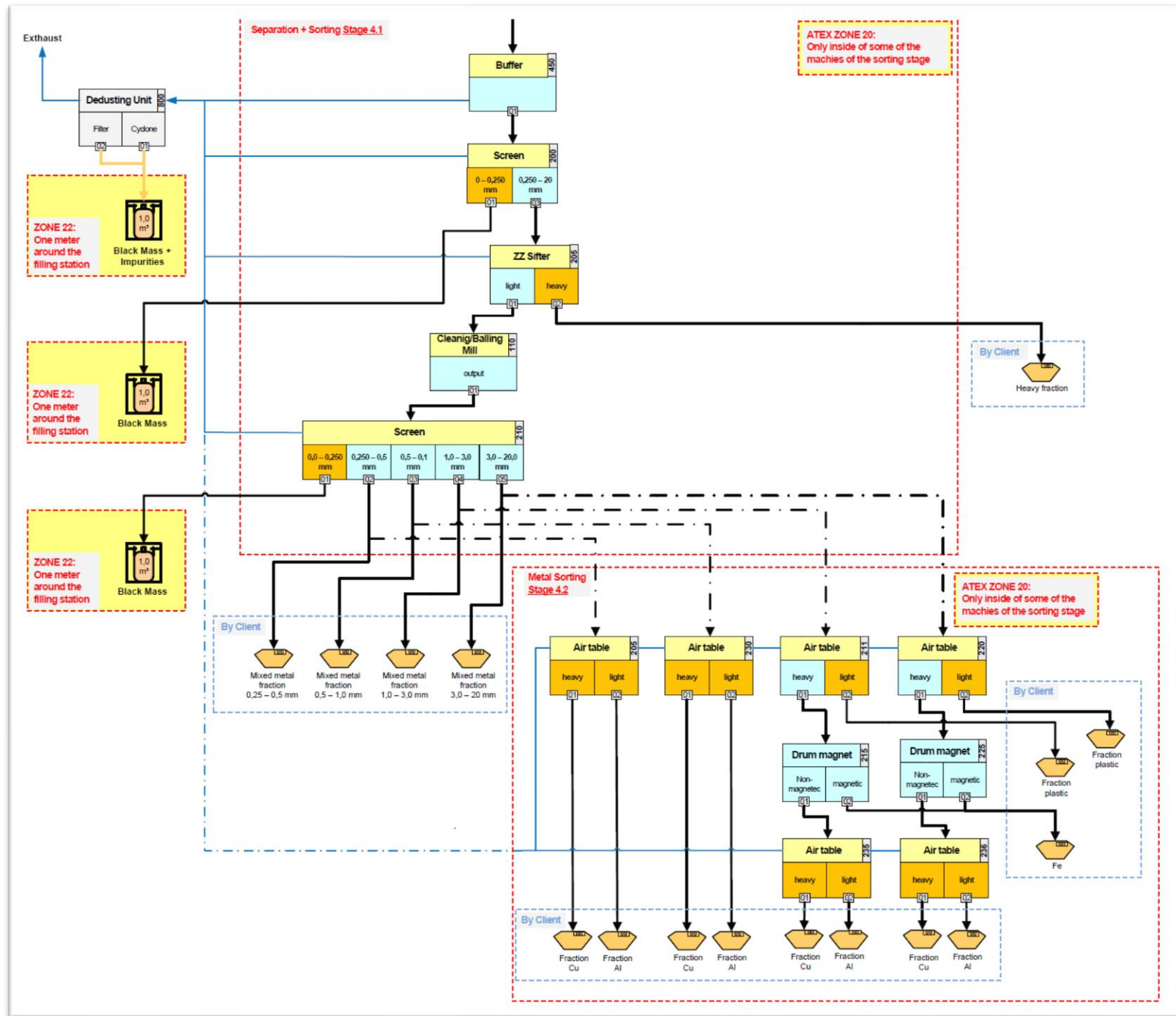
# **BHS Horizontal Evaporator Vacuum Dryer 2 x 2 tons/hour each**





# BHS Recycling Solution

## Overall Process: Stage 4: Classification & Sorting



<https://northvolt.com/press-kit/>

# BHS Recycling Solution

## Overall Process: Stage 4: Classification & Sorting



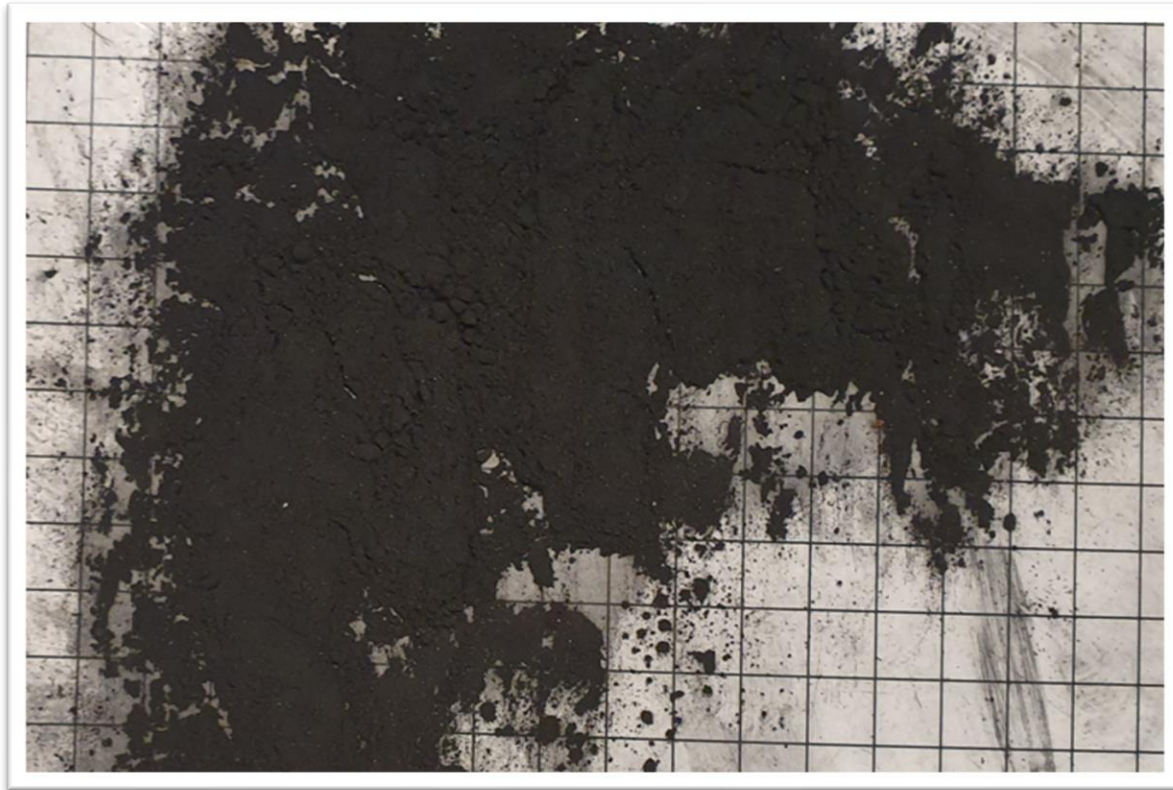
### Northvolt Revolt Ett

All material may be used in both print and online media with reference to Northvolt



# BHS Recycling Solution

## Overall Process: Stage 4 Output



**Black Mass**



**Mixed Materials**

# PDE-Stages

## **PDE-Stage 1: Preliminary Engineering**

## **PDE-Stage 2: Detailed Engineering**

P&IDs, PLC control philosophy and specification, detailed equipment specifications and other documents to allow client to issue purchase orders.

## **PDE-Stage 3: Project Execution**

Assistance is provided, as necessary, to the client engineering teams and/or outside contractors, etc. to enable the project to be completed on-time within budget.

## **PDE-Stage 4: Commissioning and Startup**

Supervision is provided to oversee vendors for cold and hot commissioning, startup, training and other on-site activities.

## **PDE-Stage 5: Support**

Guidance is provided for on-going operation, optimization and other recycling plant activities along with assistance with vendor support.



## **PDE-Stage 1 Scope of Work:**

- a. Process Description**
- b. General sizing approach including number of pieces of equipment such as one granulator and one dryer or two lines or another ideas/approaches.**
- c. Preliminary Block Flowsheet (PFD) including Discharging, Crushing/Shredding, Drying with vacuum/condensation, Gas treatment and Sorting**
- d. Final PFD**
- e. Equipment description and general specifications / information**
- f. Utility consumption and motor lists**
- g. Emissions**
  - 1. Exhaust gas flows**
  - 2. Exhaust dust flows**
  - 3. General discussion and range of emissions**
  - 4. Brine renewal/disposal based upon the battery quality and other factors**
- h. Building footprint sketch including height requirements (Outside dimensions only, building layout details are part of PDE-Stage 2)**
- i. Equipment cost estimate +/- 20%**
- j. PDE-Stage 2 engineering cost estimate**

## **PDE-Stage 2 Scope of Work:**

- a. PDE-2 SOW is based solely on the vendor selection by P&ID with the BHS Vacuum Dryer, Crusher & Shredder and other domestic/European suppliers.**
- b. P&ID drawings for each step in the process, based upon the PFDs in PDE-1. This is estimated to be six (6) P&IDs. AutoCAD “dwg formats” will be used.**
- c. PLC functional description specification and control philosophy.**
- d. Equipment specifications based upon vendor selection**
- e. The vendor selection will also result in an Approved Vendor List (AVL).**
- f. Internal building layout showing core equipment (with estimated dimensions and weights), conveying equipment and steel skid structures.
  - 1. STEP (STP) files will be used by P&ID to transfer 3D geometry models.**
  - 2. Layout will include space for incoming feed material, storage areas and other considerations for the plant.**
  - 3. The STP files will be simplified models and do not include piping with valves and instruments, air lines, electrical and wiring diagrams, etc. The STP file models can then be used by others for detailed engineering/civil/mechanical/construction/etc.**
  - 4. Building layout is based upon P&ID designs****

## **SUMMARY & TAKEAWAYS**

- **Flexible Operation for EV Modules/Cells, Production Scrap, Others (Marine, etc.) & Small-Format Batteries**
- **Dry Process – Completely Inerted & Dust-Tight**
- **Recovery of Black Mass, Electrolytes, Copper, Aluminum, Plastic and Ferrous Materials**
- **Compliance with VOC Environmental Rules & avoiding air and liquid pollutant emissions**
- **Full PDE Engineering Stages and Turnkey Systems including HAZOP Studies**
- **Operating References & Process Optimization Including Integration with Downstream Processes**

# Lithium-Ion Batteries Recycling Process

**ACT Like a Recycler  
But  
THINK Like a Chemical Plant**

**BARRY A. PERLMUTTER**  
**Perlmutter & Idea Development (P&ID) LLC**

E-mail: [barry@perlmutterideadevelopment.com](mailto:barry@perlmutterideadevelopment.com)

Website: <https://perlmutterideadevelopment.com/>

Telephone: +1.704.996.0466