

# Engineering Strategy for Design and Scale-Up of a Recycling Process

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

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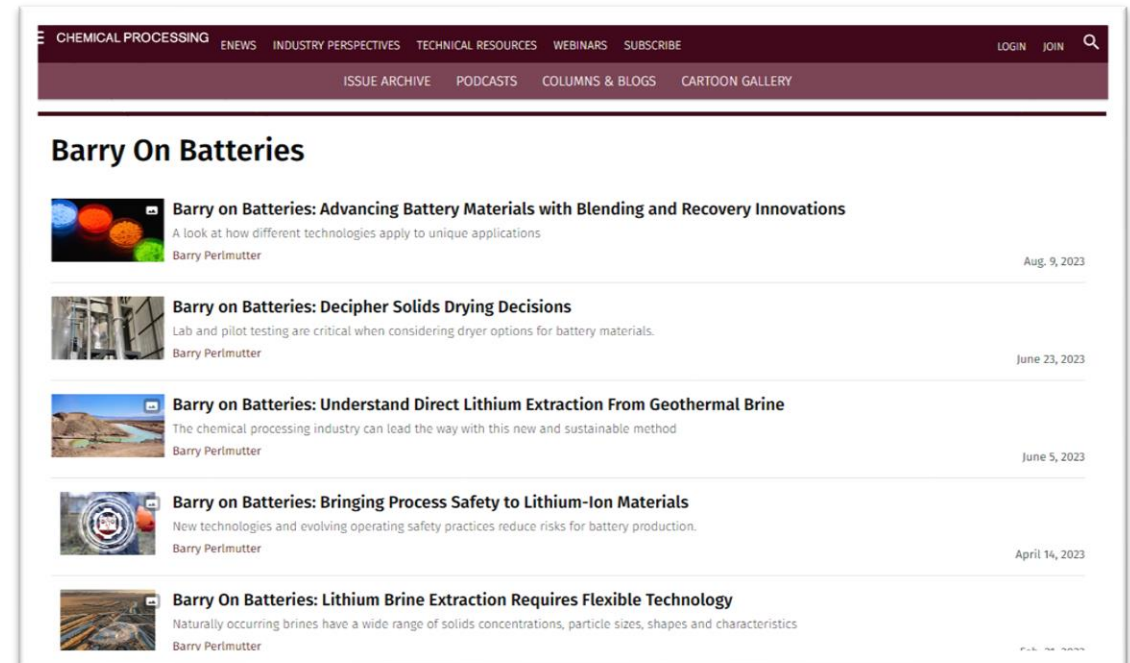
# Barry A. Perlmutter

## 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”](#)
- [On-Lithium Insights and Presentations](#)



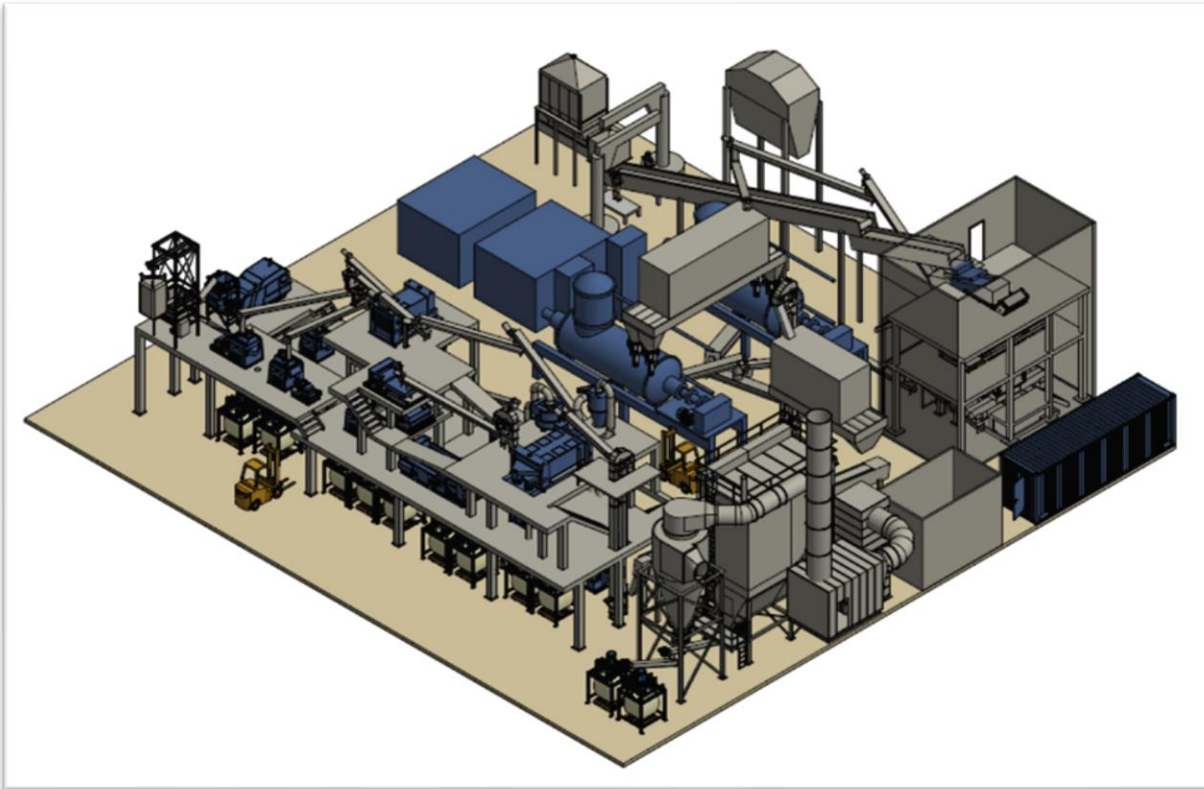
The screenshot shows the 'Barry On Batteries' website with a dark red header. The header contains navigation links: CHEMICAL PROCESSING, ENEWS, INDUSTRY PERSPECTIVES, TECHNICAL RESOURCES, WEBINARS, SUBSCRIBE, LOGIN, JOIN, and a search icon. Below the header, there are additional links: ISSUE ARCHIVE, PODCASTS, COLUMNS & BLOGS, and CARTOON GALLERY. The main content area is titled 'Barry On Batteries' and lists five 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**

- BHS-Sonthofen GmbH - Technology Provider
  - Installations Review
- Perlmutter & Idea Development (P&ID) LLC
  - Project Development Engineering (PDE) Stages

# BHS - Technology Provider Recycling Solutions



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

## 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



# Northvolt Revolt Ett



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

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

- **BHS-Sonthofen GmbH is supplying BASF with a plant for the mechanical reprocessing of lithium-ion batteries into dried 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/>



<https://www.basf.com/global/en/media/news-releases/2022/06/p-22-249.html>

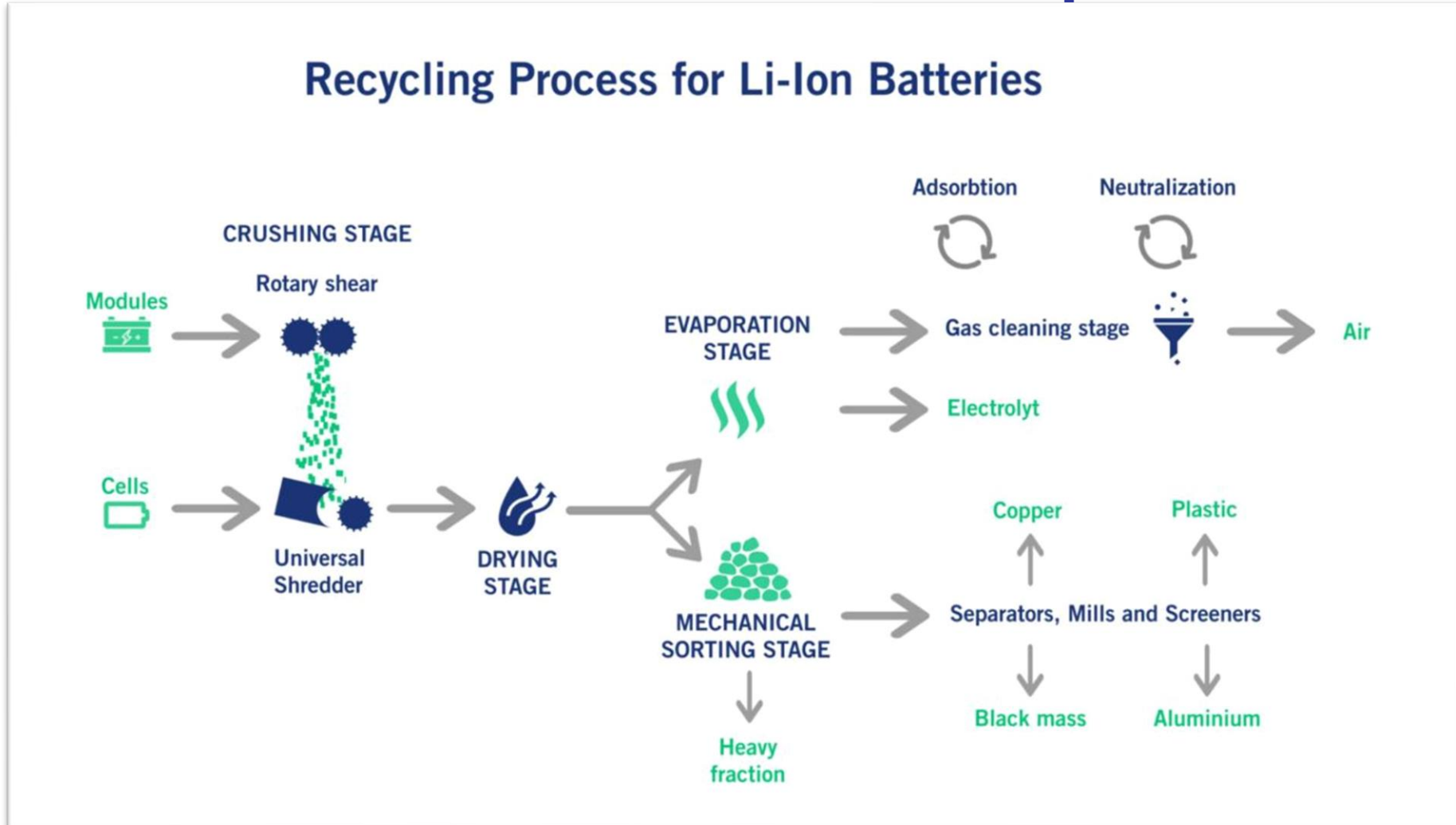




# Lithium-Ion Batteries Recycling Process For End-of-Life (EOL) Packs, Modules & Cells, Production Scrap & Defective Battery Cells & Small-Format Consumer Batteries

- Step 0: Deep discharging of batteries
- Step 1: Dry (inerted) shredding/crushing → granulating
- Steps 2/3: Black mass vacuum drying with gas treatment, electrolyte recovery & dedusting
- Step 4: Dust-tight classifying and sorting into different fractions and bagging/solids handling

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



# PDE Stages 1 - 5

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

Process Descriptions, PFDs, input/outputs, general equipment descriptions and layouts.

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

Assistance is provided, as necessary, to support the client engineering teams and/or outside contractors including drawings, HAZOP studies, vendor management, etc.

## **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, BHS Crushing/Shredding, BHS 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 1 Scope of Work:

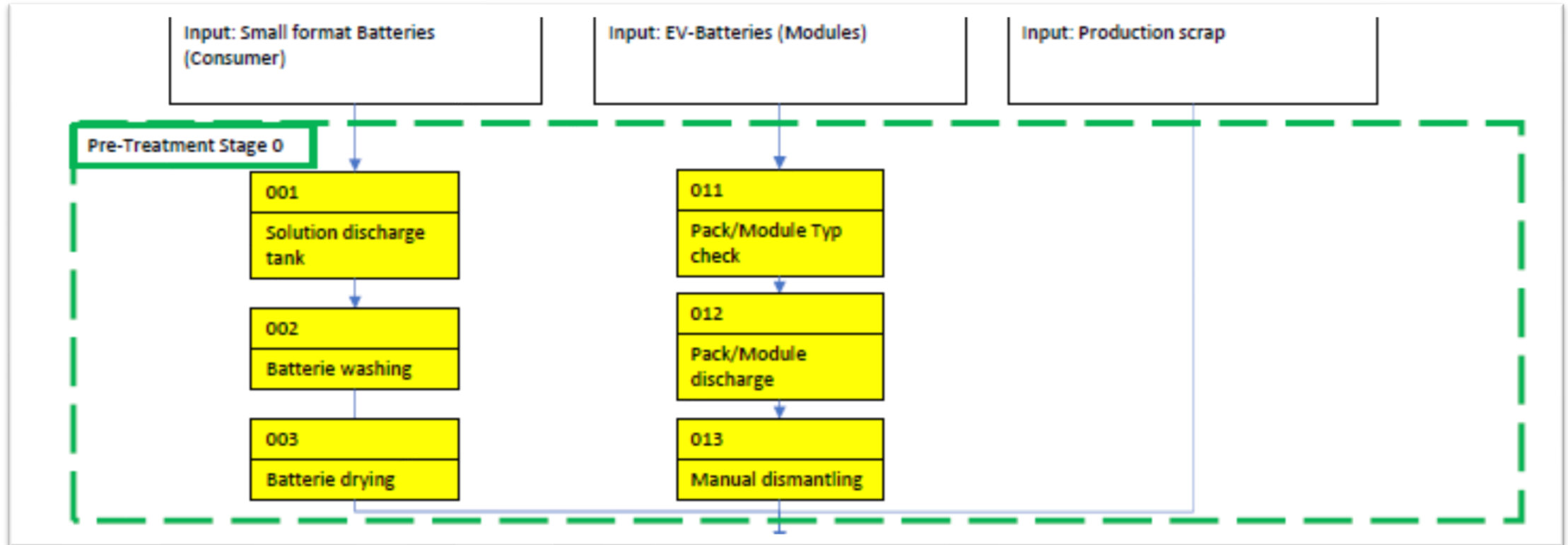
## a. Process Description

1. Throughput
2. Input specification
3. Operation time
4. Project Example

Input Type	Input Amount	Unit	Duration	Distribution		Comments	
EV Batteries	10,000,000	lbs	year	4,536	ton/year	19%	Large Format EV Batteries
Small-Format Batteries	42,800,000	lbs	year	19,414	ton/year	81%	Button Size, Power Tool Size, etc.
Production scrap	?			?			?
Overall	52,800,000	lbs	year	23,950	ton/year		24,000 M-tons/year (1 M-ton = 1.000 kg)
Plant Operation Time	20	h	day				
Plant Operation Time	6	days	week				
Plant Operation Time	50	weeks	year				
Overall	6000	h	year				
Throughput per hour	8800	lbs	hour	4.0	ton/hour		

# BHS Technology Provider Recycling Solutions

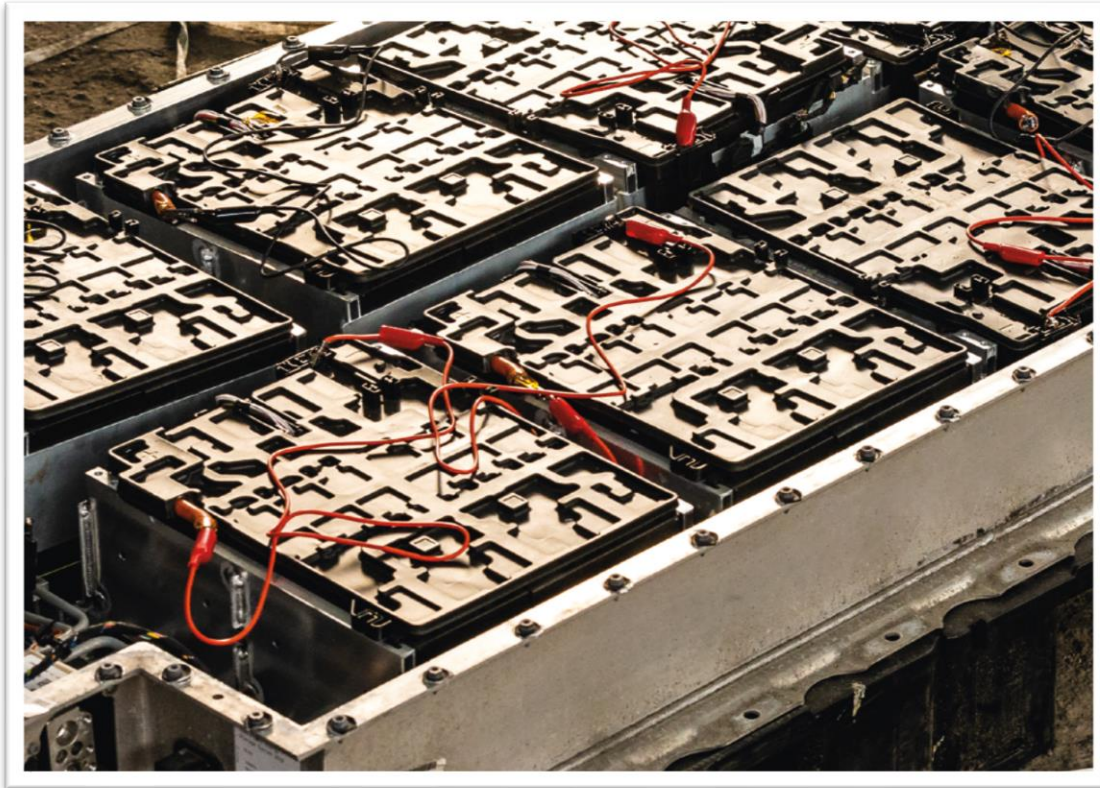
## Step 0: Discharging





# BHS Technology Provider Recycling Solutions

## Step 0: Discharging



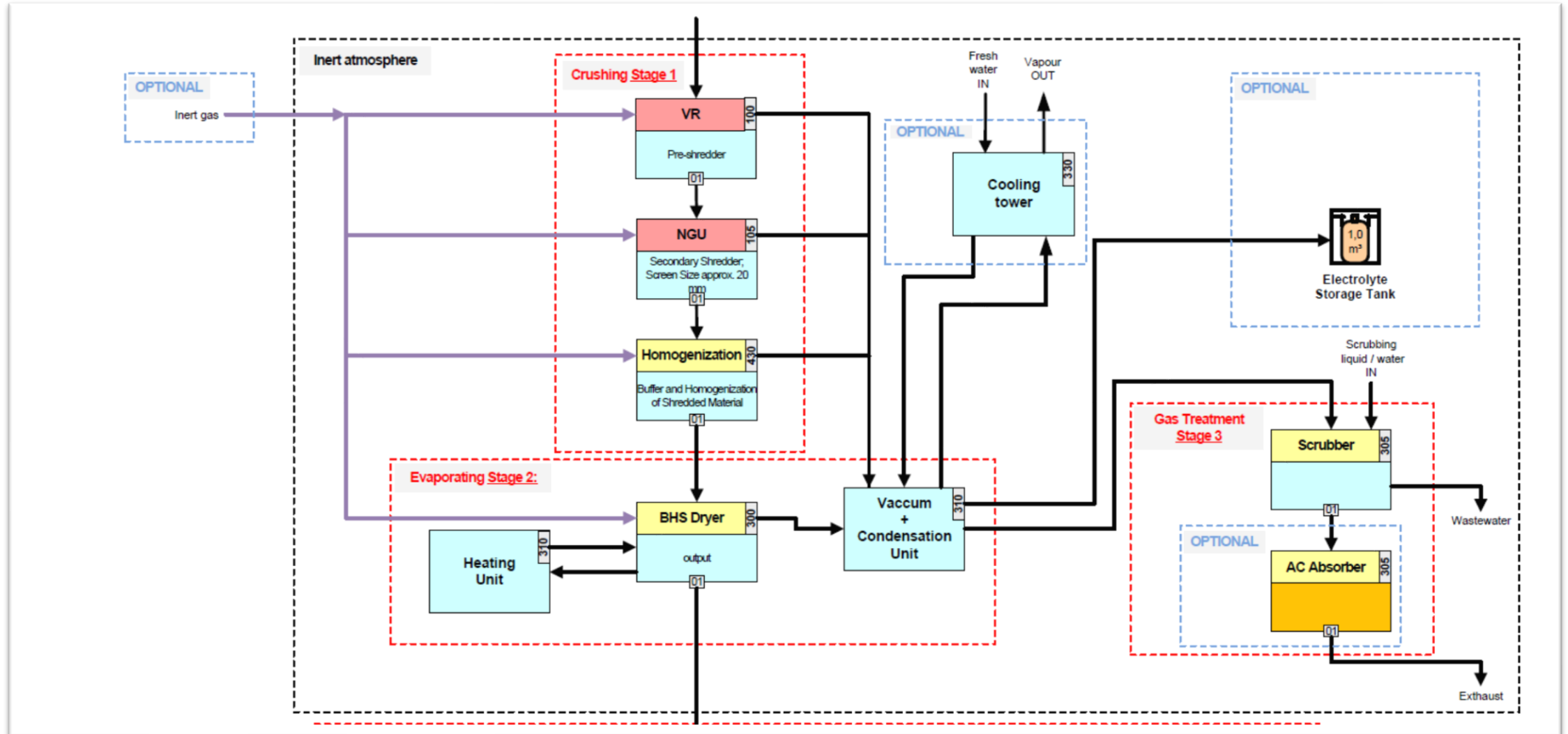
**Modules**



**Production Scrap**

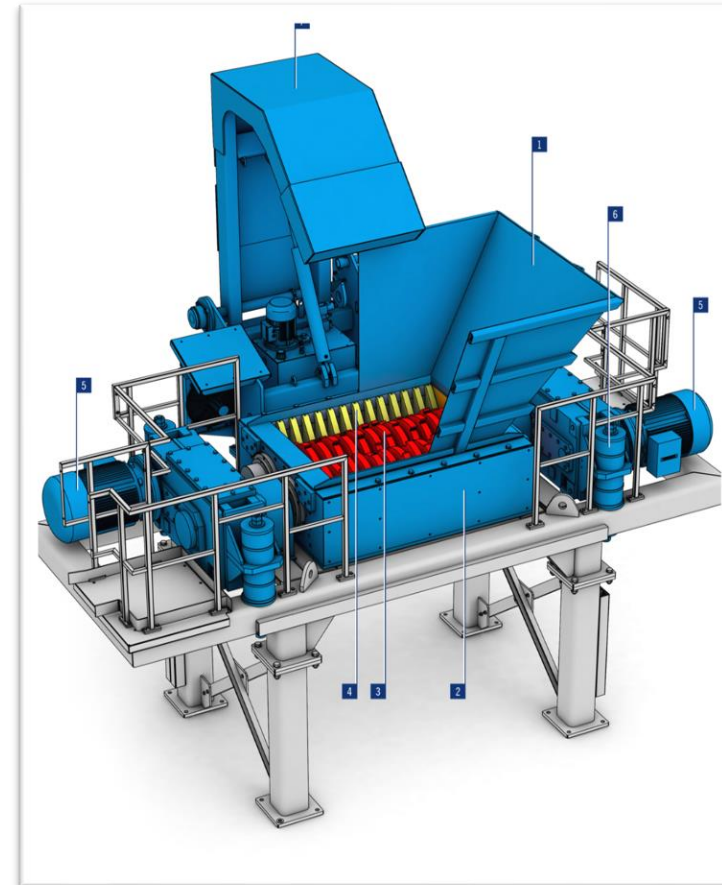
# BHS Recycling Solutions

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



# BHS Rotary Shear VR Pre-Shredder

## Step 1: Shredding/Crushing



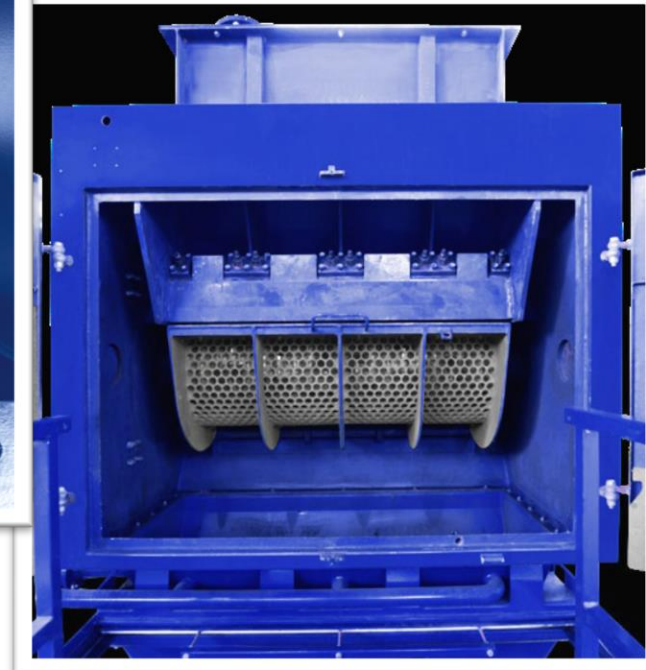
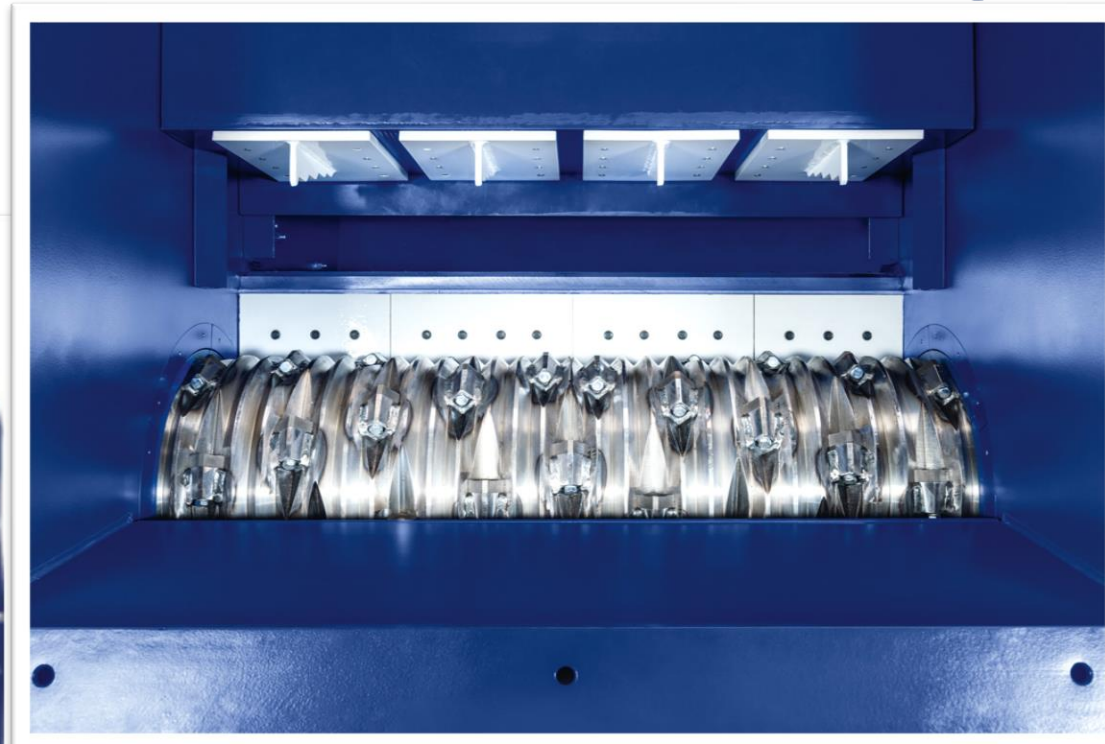
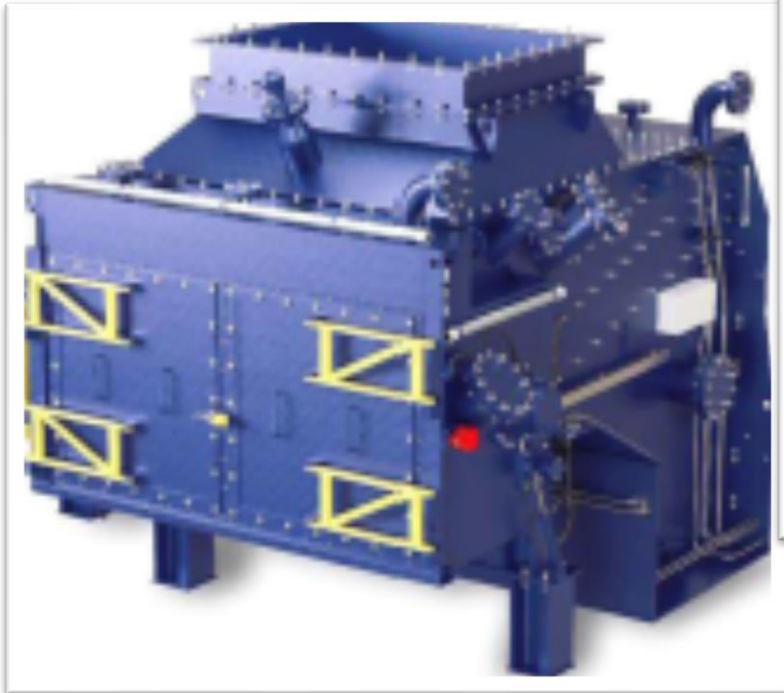


# BHS Rotary Shear VR Pre-Shredder Output



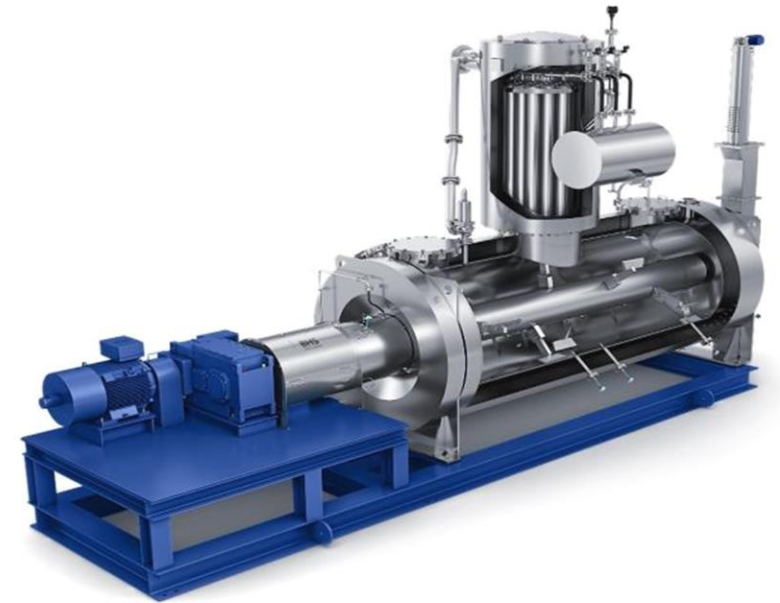
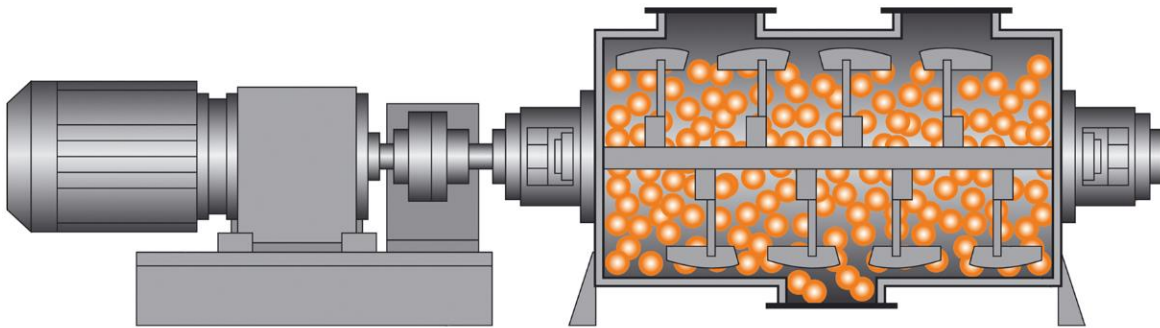
# BHS Universal NGU Granulator

## Step 1: Granulating



# BHS Horizontal Evaporator Vacuum Dryer

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





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

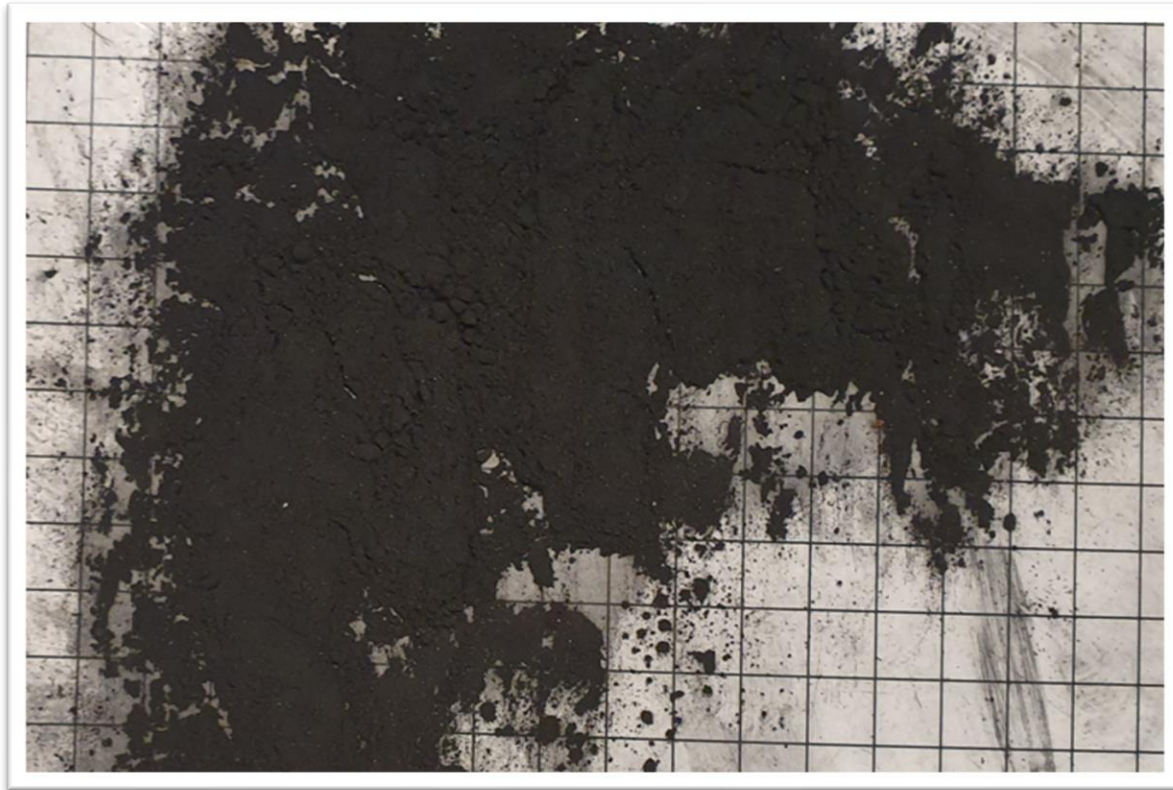






# BHS Recycling Solutions

## Step 4: Output



**Black Mass**



**Mixed Materials**

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

- 1. The PDE-2 provides design recommendations & information for client to finalize detailed engineering for project purchasing & construction.**
- 2. P&ID drawings (AutoCAD dwg formats) for each step in the process, based upon the PFDs in PDE-1 are used.**
- 3. Plant functional description specification (FDS)**
- 4. Equipment specifications**
- 5. Internal building layout showing core equipment (with dimensions and weights), conveying equipment and steel skid structures.**
  - a. STEP (STP) files will be used to transfer 3D geometry models.**
  - b. Layout will consider material storage, receiving and other logistics and building requirements as specified by client.**
  - c. The STP files will be simplified models that can then be used by others for detailed engineering/civil/mechanical/construction/etc.**
  - d. Building layout based upon P&ID designs and client footprints.**



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

## **A. Crushing step 1**

- 1. Feeding Systems-Conveyors-Tanks**
- 2. BHS process system for shredding/crushing:**
  - **BHS Lock**
  - **BHS Rotary Shear (Pre-shredder)**
  - **BHS Granulator**

## **B. Drying steps 2/3**

- 1. BHS process system for drying:**
  - **BHS Horizontal Vacuum Dryer**
  - **BHS Vacuum and Condensation unit**
- 2. Gas Treatment for VOC**

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

## **C. Sorting Step 4**

- 1. Conveyors-Tanks-Screening/Sifter (Zigzag)/Mills**
- 2. Gas Treatment for TSP**
- 3. Solids Handling equipment**

## **D. Ancillary Skid packages with Piping, Valves and Instruments, Steel Structure including Nitrogen system and Air compressor**

## **E. Plant Operation and Controls Integration**

## **F. Discharging Pre-Treatment Step 0**

- 1. Discharge with liquid brine solution for small-format batteries**
- 2. Discharge with electrical return feed for EV batteries**

# PDE-Stages

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# SUMMARY & TAKEAWAYS

- **Flexible Operation:**  
EV Packs/Modules/Cells, Production Scrap, Others/Marine,  
& Small-Format Batteries/Power Tools
- **Dry Process:** Completely Inerted & Dust-Tight
- **Recovery:** Black Mass, Electrolytes & Mixed Materials
- **Compliance:**  
VOC and TSP Environmental Rules/no wastewater emissions
- **Full PDE Engineering Stages and Turnkey Systems:**  
HAZOP Studies for Safe Operation
- **Operating References & Process Optimization:**  
Integration with Downstream Processes



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