SOLID STATE BY PROLOGIUM: BETTER PERFORMANCE AND LOWER COST

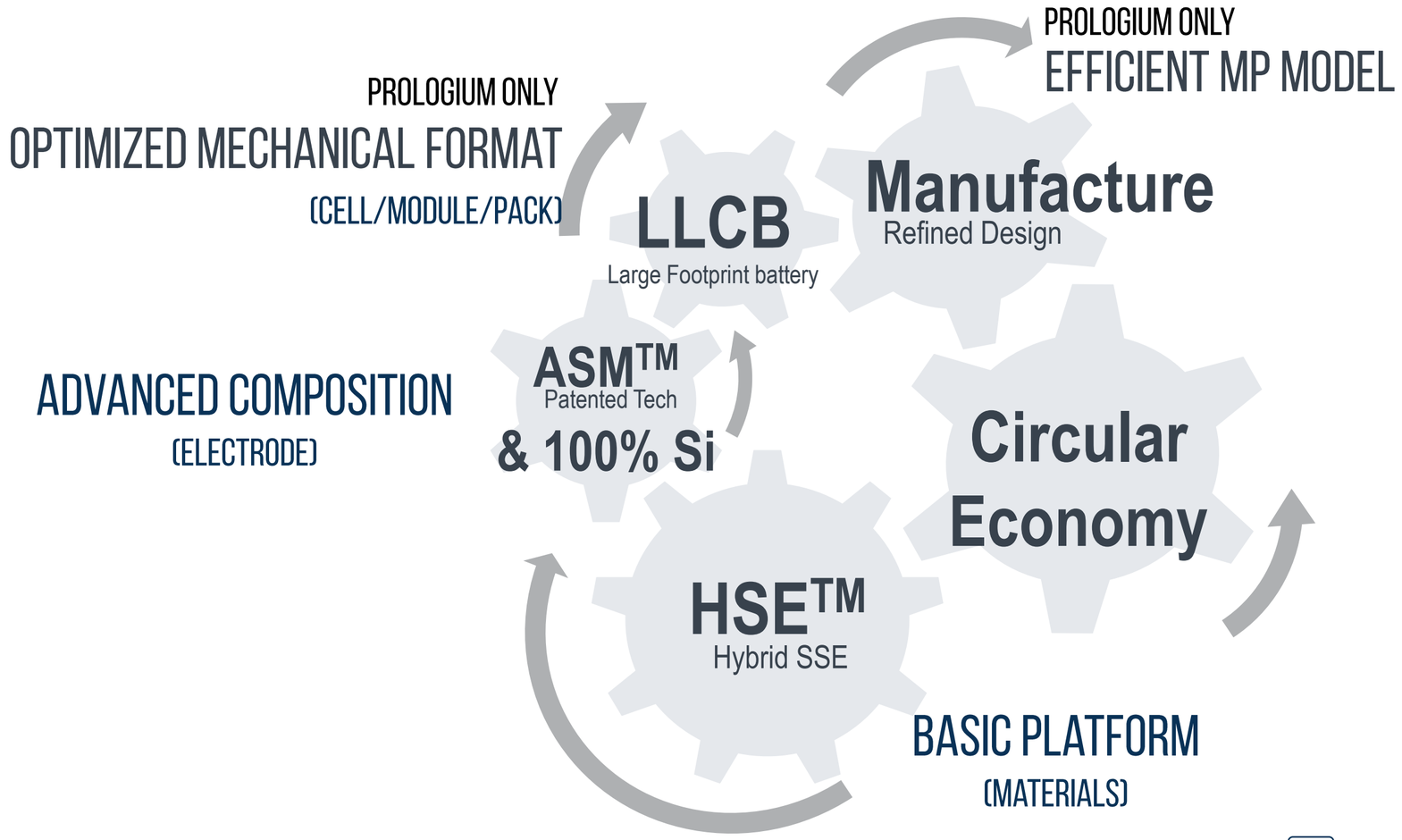
WORLD MATERIALS FORUM

7th July 2023

ProLogium

SIMPLE IS MORE

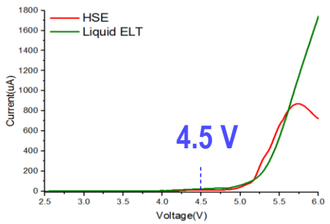
THE WORLDWIDE FIRST “P-C-R (BALANCED PERFORMANCE-COST-RESOURCE) NEXT GENERATION BATTERY”

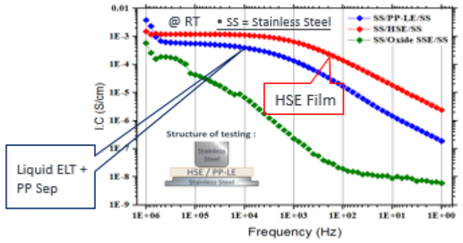


BASIC PLATFORM : HSE (HYBRID SOLID STATE ELT - OXIDE + SPE)

SOLVE THE INTERFACE IMPEDANCE ISSUE, AND IMPROVE ION CONDUCTIVITY

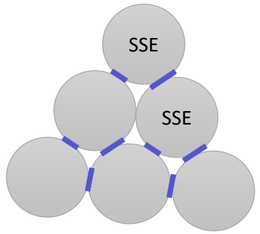
1. Interface between solid electrolyte and solid electrolyte



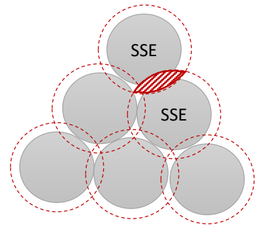


Before

- Contact area is little.
- Ion conductivity is poor at 10^{-8} S/cm

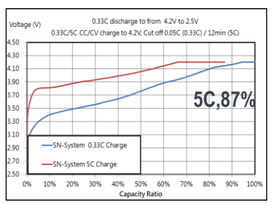


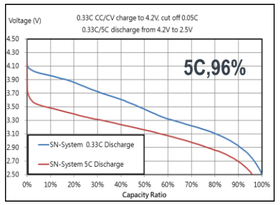
After

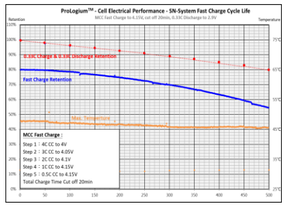


- improve ion conductivity in mid frequency area by enlarge contact area.
- 10^{-3} S/cm

2. Interface between solid electrolyte and active material inside cathode and anode

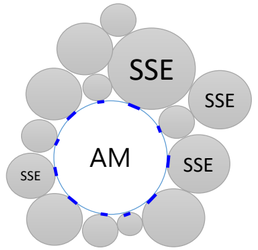




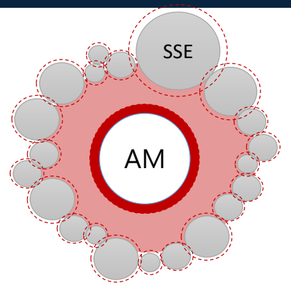


Before

- Contact area is small.
- Interface impedance is terrible.

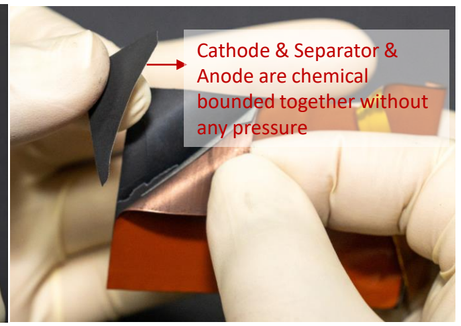


After



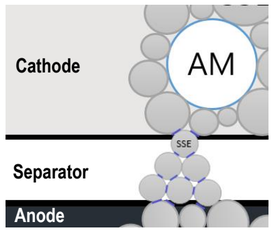
- Larger contact area.
- Decrease the interface impedance.
- Better ion conductivity.

3. Interface between solid separator and electrode

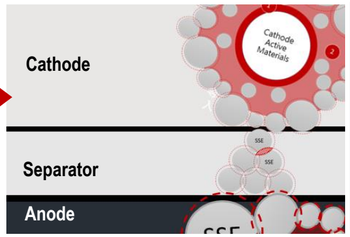


Before

- Poor ionic conductivity between Separator and Electrode



After



- Enhance the Interface Ionic conductivity between Separator and Electrode.

BASIC PLATFORM : HSE (HYBRID SOLID STATE ELT - OXIDE + SPE)

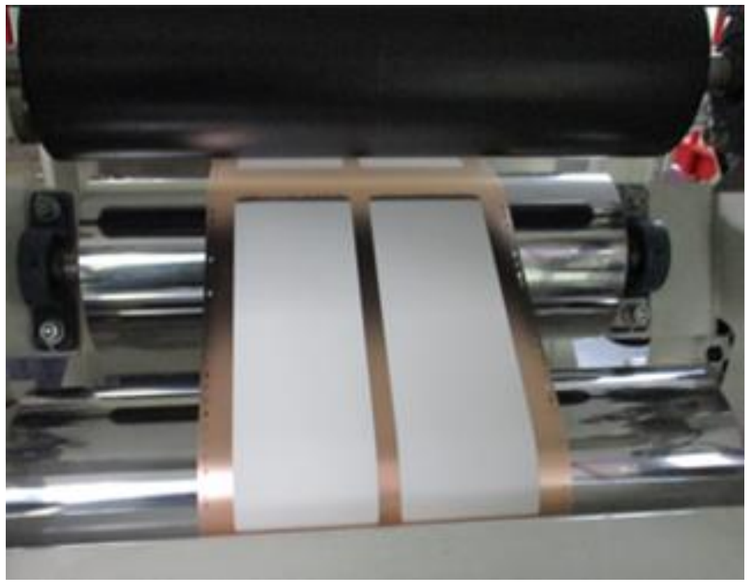
OFFER MECHANICAL & MECHANISM ADVANTAGE OF THE ELECTRODE AND CELL DESIGN

1. Provide SSL Strong Mechanical to resist outside and inside stress
   => 100% Si and Li metal anode (Large Volume Change)
   => Abused Situation: outside Impact

Strong Mechanics

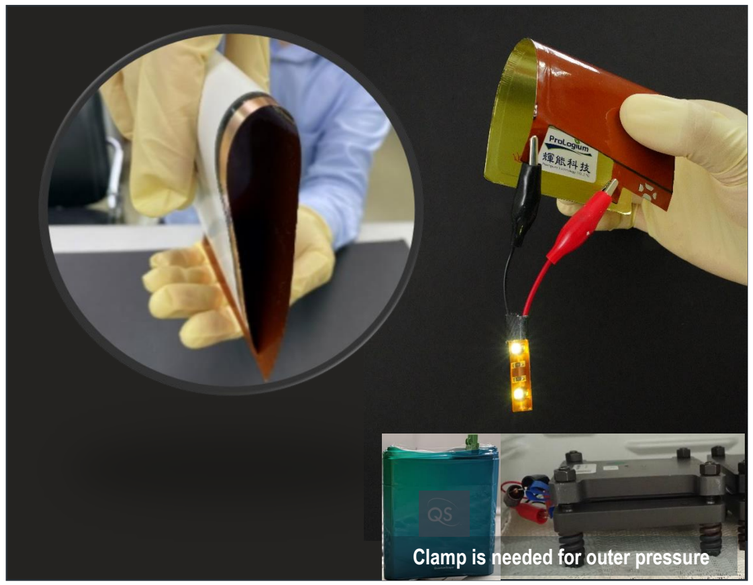
2. Wet Film Coating & Dry Film Extrusion can be used
   => enhance the Roll-to-Roll MP Capability
   => enhance the Yield ratio of the MP

Scalability & High Ionic Conductivity



3. Good inteface adhesive between electode and Separator.
   => Good for the Roll-to-Roll MP Capability.
   => No need Additional Pressure for battery operation

Enable Roll-to-Roll Automotive Production

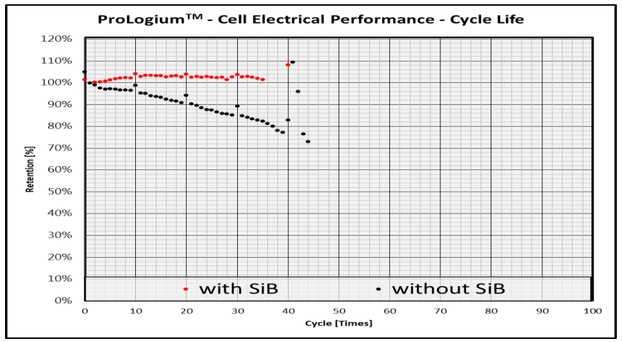


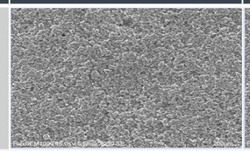
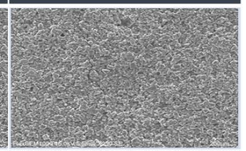
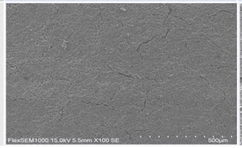
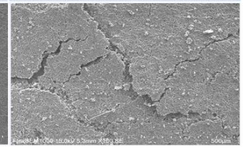
ADVANCED COMPOSITION: 100% SI AND ASM(ACTIVE SAFETY MECHANISM)

Si Anode

Patented SiB™

1. Patented SiB technology inhibit the volume change of silicon and reduce the electrode damage caused by the stress of silicon swelling.



	With SiB	Without SiB
Before formation		
After formation		

Patented Si Composite Material

	Si Composite	SiOx	Graphite
Utility	(now) **2600-2800mAh/g** (theoretical) **4000mAh/g**	(now) **1300-1400mAh/g** (theoretical) **1800mAh/g**	(now) **360mAh/g** (theoretical) **372mAh/g**
Rate	◎	○	△
CE	**92-93%**	**88%** (with Lithiation) **74%** (w/o Lithiation)	**91-93%**
Cost/Wh	**US$ 2/KWh** (R.M.) US$ 20/Kg	**US$ 12- 20/KWh** (R.M.) US$ 60-100/Kg	**US$ 6-8/KWh** (R.M.) US$ 8-10/Kg
Cost	**1x**	**6-10X**	**3-4X**

ASM™

Patented ASM™

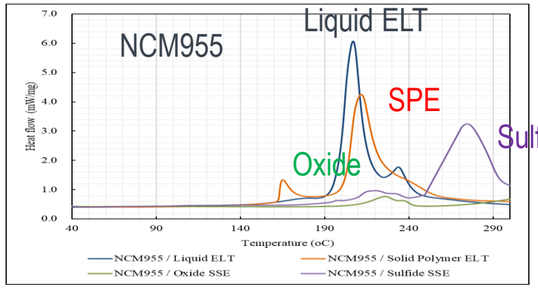
- ✓ Active Safety mechanism = Oxide safety
- ✓ Replace HSE for material cost reduction (refer to the right table)

	ASM	HSE
Usage amount	**<5%** CA/AN	**>30%** CA/AN
Unit cost ($)	**low**	**high**

Oxide

Is the most stable ELT

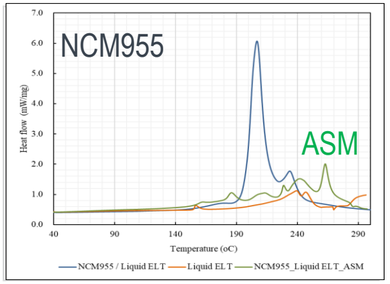
(Passive safety)

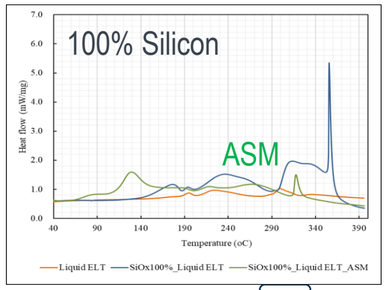


ASM

can stabilize Cathode & Anode

(Active safety)





WITH BASIC AND ADVANCE TECH TO BALANCE CELL PERFORMANCE AND COST

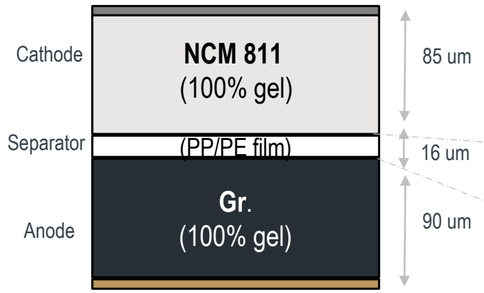
Safe

High Energy Density, High C-Rate, Low Cost

Thick Separator → Thin Separator

Liquid Type LiB

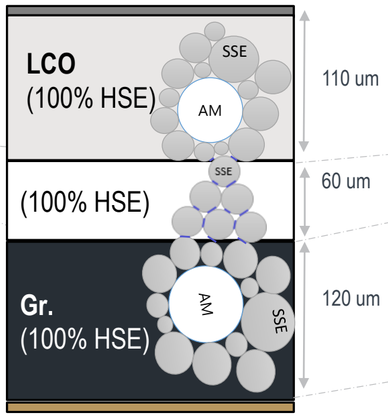
260-280Wh/kg



- ☐ Safe
- ☑ **Energy Density**
- ☑ **C-Rate: 3C**
  - _ACIR: 1.5mΩ
  - _DCIR: 2.23mΩ
- ☑ **Cost**

(1st LCB System)

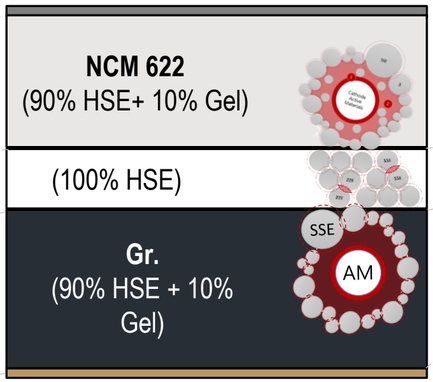
150Wh/kg



- ☑ **Ultra Safe**
- ☐ Energy Density
- ☐ C-Rate: 0.2-0.5C
  - _ACIR:19mΩ
  - _DCIR:38mΩ
- ☐ Cost

(2nd LCB System)

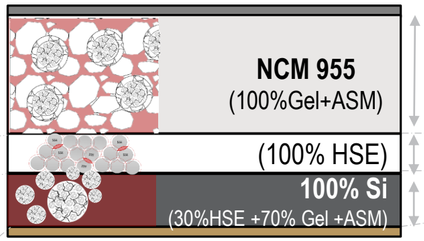
225Wh/kg



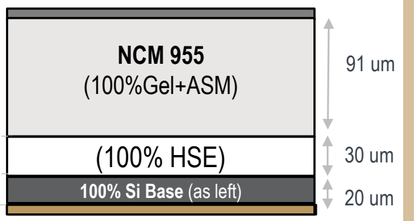
- ☑ **Ultra Safe**
- ☐ Energy Density
- ☑ **C-Rate: 3C**
  - _ACIR: 1.16mΩ
  - _DCIR: 2.54mΩ
- ☐ Cost

(3rd LCB System + ASM)

320Wh/kg

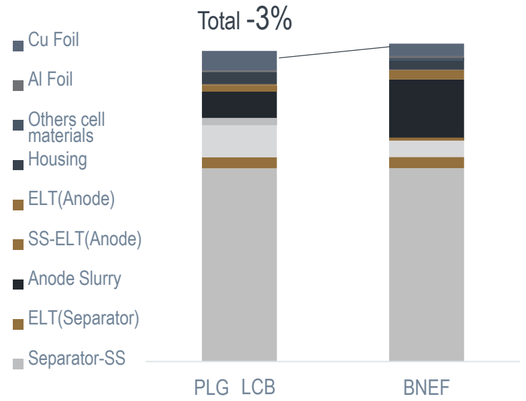


360-380Wh/kg



- ☑ **Ultra Safe**
- ☑ **Energy Density**
- ☑ **C-Rate: 5C**
  - _ACIR: 0.67-0.62mΩ
  - _DCIR: 2.38-2.05mΩ
- ☑ **Cost**

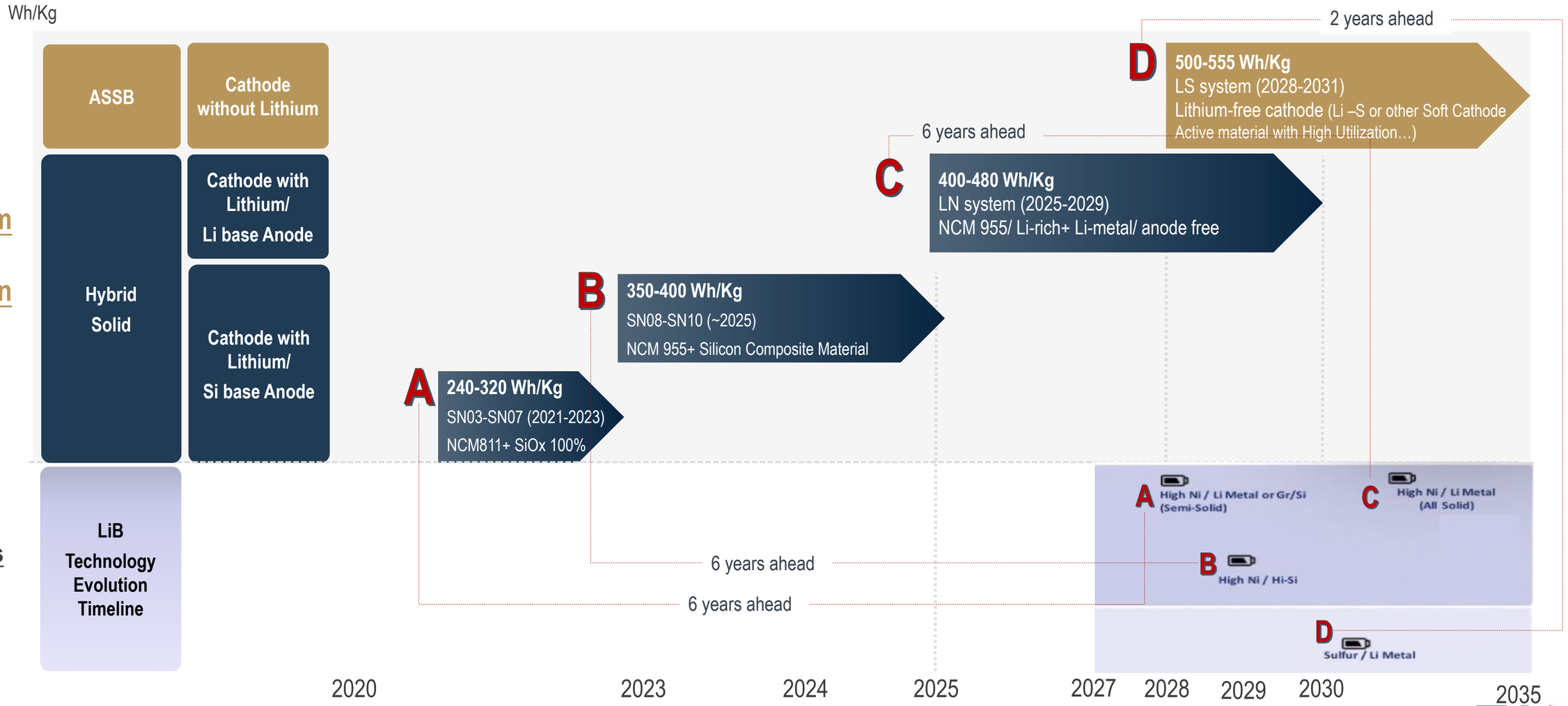
Cost is lower than Liquid LiB @10GWh



Balance Performance and Cost

PROLOGIUM'S CHEMICAL ROADMAP TO MEET THE MARKET REQUIREMENT

2-6 years ahead of LiB technology Evolution Timeline.



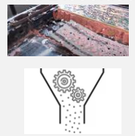
OUTSTANDING RECYCLABILITY (PACK)

4680 Cylindrical

Recycle process

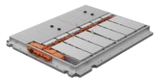
Pack

Module (difficult to separate)



Pack Dissolution

VDA590 Pouch



Pack

Module

Module Dissolution

Extraction & Separation

Hydrometallurgy → Acid Leaching → Precipitation

Pyrometallurgy → Calcination → Toxic Gas → Reductive smelting

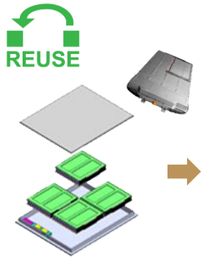
Complex feed-in material leads to complicated recycle process (costly)

Thus
1. Low recyclability & reusability
2. Energy Consumption ↑、$eCO2/cm^2$ ↑、Pollution ↑

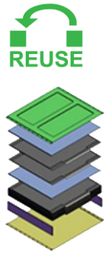
1. NCM Scarp

Low Quality NCM

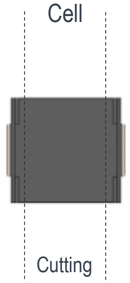
PLG LLCB



Pack



Module (Mini Pack)

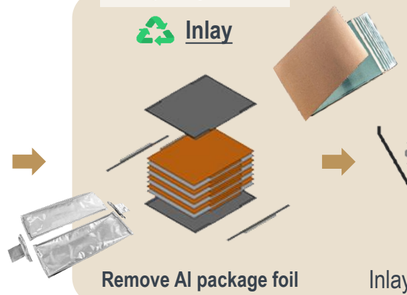


Cell

Cutting

Recycle process

Inlay



Remove Al package foil

Inlay Dissolution

Centrifugal Decanter

Simple feed-in material enables easy recycle process (cost-friendly)

High recyclability & reusability

3Ls
1. Energy Consumption ↓
2. eCO_2 / cm^2 ↓
3. Pollution ↓

1. NCM
2. SSE

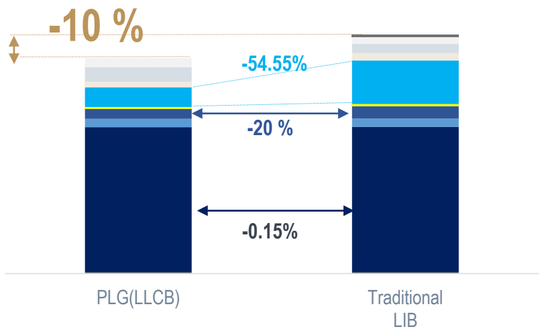
High Quality Density

Cost Comparison

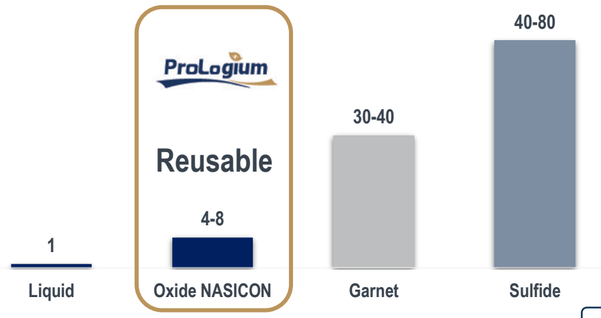
COST COMPARISON BREAKDOWN (PACK)

	PLG	CTP	VDA
Cost Optimised After Recycle	8	0	3
Cost per Pack	12	15	22
Cost per In-pack Cell	100	112	112

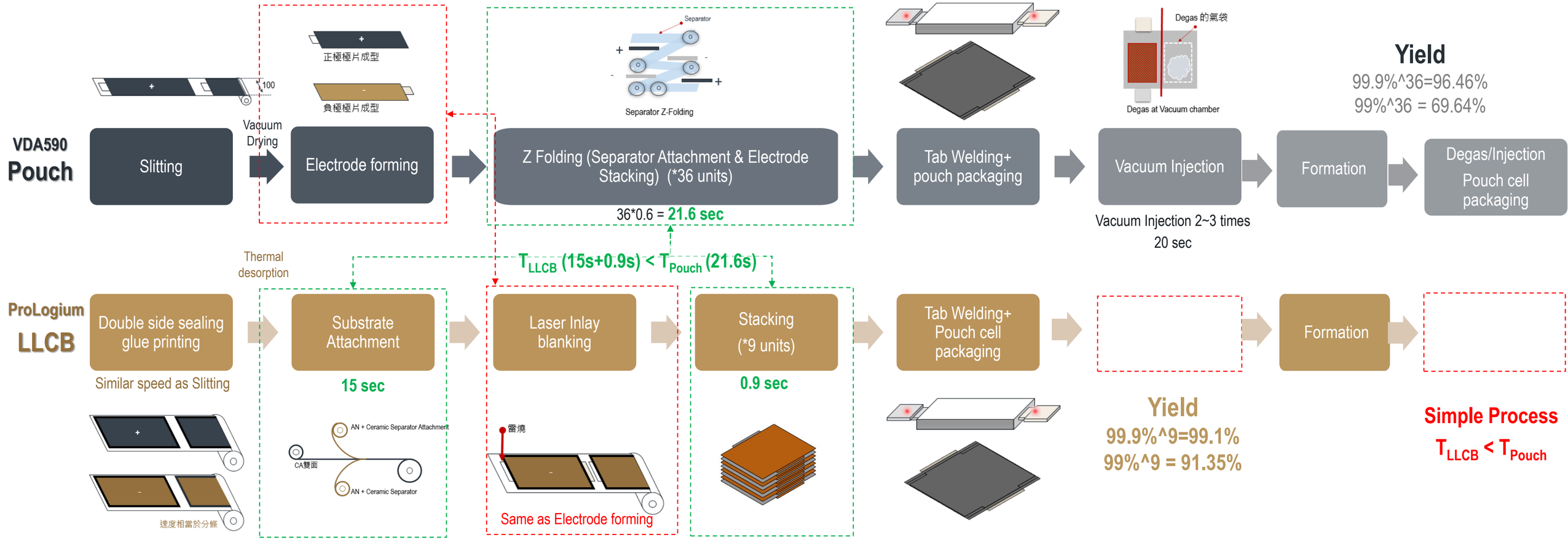
Cost Advantage of Recyclable Separator & ELT



Li Resource Consumption Comparison by ELT Type



PROLOGIUM HIGH THROUGHPUT MANUFACTURING TECHNOLOGY TO LOWER THE COST



LLCB throughput is 2-3x, Pack cost reduce 20~30%

Energy : $E_{LLCB} \fallingdotseq 3*E_{Pouch}$ — LLCB = 3 times of the VDA 590 Pouch (indicates better throughput efficiency)

Duration : $T_{LLCB} < T_{Pouch}$ — LLCB's duration is generally shorter than the VDA 590 Pouch

Yield rate : $T_{LLCB} > T_{Pouch}$ — Yield rate tends to be higher than traditional process & more operation window

$$\frac{E_{LLCB}(Wh)}{T_{LLCB}(min)} > \mathcal{X} * \frac{E_{Pouch}(Wh)}{T_{Pouch}(min)}$$

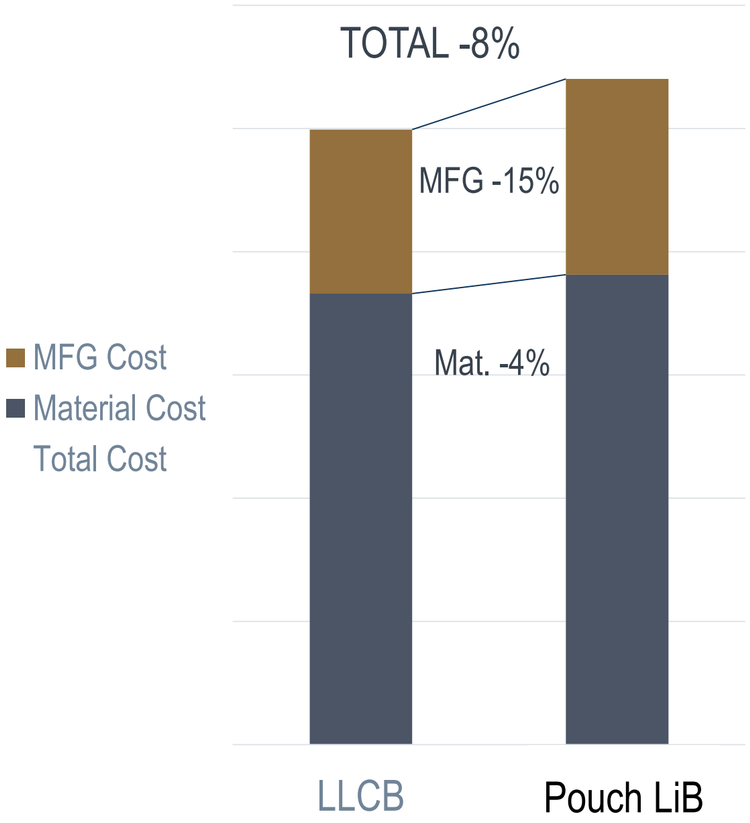
Better production efficiency
Reduced cost

$\mathcal{X} \fallingdotseq 2\sim3$

PROLOGIUM HIGH THROUGHPUT MANUFACTURING TECHNOLOGY TO LOWER THE COST

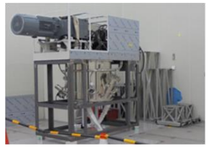
Localizing value chain in France

COST ADVANTAGE OF MANUFACTURING



TAOKE EQUIPMENT 2023/E START PRODUCTION

TAOKE FACTORY 1F


Slurry mixer (upper unit)


Slurry mixer (lower unit)


Coater (loading unit)


Coater (unloading unit)


Flexographic printer


Coating Dryer


Roll Splicer


Dry oven


Film attachment


QR code generator

TAOKE FACTORY 3F


Electrode assembly (I)


Electrode assembly (III)


Screen printer


Electrode assembly (II)


Pre-assembly process tool


Electrode assembly (IV)


Electrode assembly (V)

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