OUTLINE

About ProLogium (PLG)
Solid State Battery (SSB)
PLG's Core Technology
Applications
ProLogium

The only SSB maker with mass production capability and commercialized experience

Key figures

Founded: 2006
Location: Taoyuan, Taiwan
Employees: 460 (2019/1)
PLG owned 100% Patents
Patents: 212 (2019/5)
PLG Milestone

2006
Founded

2006
FPC Type LCB
Announced

2012
FLCB
Announced
Pouch Type LCB
Supply HTC

2012
PLCB
Commercialized

2014
G1 Line MP
RTR Automatic Line
Production Capacity
40MWh / year

2017
G2 Line
Construction Began
BiPolar+ Type LCB
Production Capacity
1~2GWh / year

2018
MAB
Announced
Multi-Axis BiPolar+ Pack

2019
BLCB
Announced

Production Capacity

Current Production Capacity: 40MGwh
2021 Production Capacity: 1~2GWh

G1 Line
Location: Taoyuan, Taiwan
Area: 11,000 m²
Production Capacity: 40MWh
MP @2017

G2 Line
Location: Taoyuan, Taiwan
Area: 60,000 m²
Production Capacity: 1~2GWh
MP @2020~2021
Production Line

FPC Type

- Ultra thin 0.43mm
- Flexible (R40, 7,000 times)
- Tubular type: TLCB
- Logic circuit adoptable
- Good pressure durability: $10^{-11}$ ATM ~ 680 ATM

FPC Type

Bipolar+ Technology
- Series/parallel inside cell
- High voltage (8.4V~49V)

Pouch Type

- Fast charge ability:
  - 2018: 70% in 12 mins
  - 2019: 90% in 12 mins
- Discharge @ -40°C~115°C
- Storage @ -65°C~115°C

FLCB

- Multi-Axis Bipolar+ Pack
  - Multi Axis Bipolar+ technology, only 1/1000 cell amount
  - Simplify protection mechanism, cooling system and BMS to increase assembly efficiency in volume and weight
  - 70% weight, 50% volume and 70% cost of traditional battery pack

BLCB

MAB

- Multi-Axis Bipolar+ Pack
  - Bipolar+ technology
  - Series/parallel inside cell
  - High voltage (8.4V~49V)
PLG Global Patents Distribution

PLG’s 100% exclusive patents distribution in EU, US, China and Japan

Patents over the years

<table>
<thead>
<tr>
<th>Year</th>
<th>Patents</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>31</td>
</tr>
<tr>
<td>2013</td>
<td>49</td>
</tr>
<tr>
<td>2014</td>
<td>58</td>
</tr>
<tr>
<td>2015</td>
<td>58</td>
</tr>
<tr>
<td>2016</td>
<td>74</td>
</tr>
<tr>
<td>2017</td>
<td>128</td>
</tr>
<tr>
<td>2018</td>
<td>212</td>
</tr>
</tbody>
</table>

Core Tech: LCB
- Issued: 129
- Filed: 83

Specific Equipment
- Application: Cover Battery, Watchband Battery
- Sealicone Tech (Package Mechanism)
- BOF Tech (Battery on FPC Substrate)
- Lithium Tech (Lithium-Metal System)
- Ceramion Tech (Lithium Ceramic Electrolyte)
Testimonial

This game changer design provide EV battery pack with 70% cost, 50% volume, 80% weight and the key is, an intrinsically safe promise to users.

—Edison Award
Solid-State Battery

Lithium Battery System Evolution
Solid State Electrolyte Comparison
SSB Market Status
SSB MP Progress
Battery System Evolution

Users are always pursuing higher energy density and stability

<table>
<thead>
<tr>
<th>Material</th>
<th>Safety</th>
<th>E.D.</th>
<th>Life</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTO</td>
<td>O</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>LiFePo4</td>
<td>O</td>
<td>X</td>
<td>X</td>
<td>O</td>
</tr>
<tr>
<td>LMO</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>O</td>
</tr>
<tr>
<td>NMC</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>O</td>
</tr>
<tr>
<td>LCO</td>
<td>O</td>
<td>X</td>
<td>X</td>
<td>O</td>
</tr>
</tbody>
</table>

Battery system with Liquid ELT/PP,PE separator vs. Battery system without Liquid ELT/PP,PE separator

(at same MP scale)
### Solid State Electrolyte Comparison

#### Oxide
- **Conductivity**
  - High interface resistance is solved by Ceramion® Tech.
- **Stability**
  - Electrode brittle issue is conquered by Microcell® Tech.
- **Feasibility**
  - Best stability
  - Ultra safe

#### Sulfide
- **Conductivity**
  - Poor stability
  - “Hydrogen sulfide (H₂S)” is produced easily during battery processing and under abnormal operation
- **Stability**
  - Wet processing
  - Only few solvent can be used but each has side effect
  - Only few binder can be used but each has side effect
- **Feasibility**
  - Cost is too high
  - Semi-conductor processing

#### Thin film
- **Conductivity**
  - Poor stability, not safe
  - E.D. is limited (similar to liquid type)
- **Stability**
  - Semi-conductor processing
- **Feasibility**
  - Poor ion conductivity
  - Poor pack E.D. of 110-140Wh/L
  - High temp. and high pressure is needed at module level

#### Solid Polymer
- **Conductivity**
  - Semi-conductor processing
- **Stability**
  - Semi-conductor processing
- **Feasibility**
  - Semi-conductor processing

- **Representatives**
  - ProLogium
  - TOYOTA
  - dyson
  - Apple
  - BOSCH

- **Abandon**
  - Sakti3
  - IPS Not MP
  - Abandon Seeo
### Trend of Solid State Electrolyte

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Before 2018</th>
<th>After 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount</td>
<td>Main Players</td>
<td>Amount</td>
</tr>
<tr>
<td>Solid Polymer</td>
<td>8</td>
<td>Bosch &amp; Seeo / Solid Energy / EMBATT / Ionic Material / Qingtao / WeLion / QuantumScape</td>
</tr>
<tr>
<td>Thin Film</td>
<td>3</td>
<td>Apple (IPS) / Dyson &amp; Sakti3 / STM</td>
</tr>
<tr>
<td>Sulfide</td>
<td>7</td>
<td>Toyota / CATL / Solid Power / Samsung SDI / LGC / Hitachi Zosen / Panasonic</td>
</tr>
<tr>
<td>Oxide</td>
<td>2</td>
<td>ProLogium / Murata-Sony</td>
</tr>
</tbody>
</table>

### Notes
- **Before 2018**: The main players are Bosch & Seeo, Solid Energy, EMBATT, Ionic Material, Qingtao, WeLion, QuantumScape.
- **After 2018**: The main players are Bosch, Solid Energy, EMBATT, Ionic Material.

- **Bosch gave up automotive battery, selling Seeo.**
- **Qingtao / WeLion / QuantumScape turned to Oxide.**
- **Dyson abandoned Sakti3’s IP**
- **IPS haven’t MP since acquired by Apple**
- **Toyota turned to hybrid-oxide & sulfide**
Global SSB Development Status

Solid state battery is allocated globally since liquid type is far behind the market demand. PLG is a pioneer with MP ability in 2013, roll to roll MP in 2017 and worldwide first BiPolar+ tech.

- *Hydro-Quebec’s IREQ / Bellore (60~80C)
- Apple (IPS)
- Seeo Inc. (Bosch) 2007-2018
- QuantumScape (2025)
- SolidEnergy (2025)
- EMBatt (2025) *
- Bosch
- Solid Power (2026)
- Sakti3 (2015-2018)
- PLG **
- Ceramic thin film battery
- Solid polymer battery
- Ceramic thick film battery (Oxide ELT)
- Ceramic thick film battery (Sulfide ELT)

**"** BiPolar SSB (can be series)
***"** Advanced BiPolar(series and parallel)- BiPolar+ **

- Samsung SDI
- Panasonic (2025-2030)/S
- Hitachi Zosen
- Solid Power (2026)
- Ionic Material
- STMicroelectronics

PLG **
- 2014 SBS MP
- 2017 RTR MP
- 2017~2018: 40MWh/year
- 2020~2021: 1~2GWh/year

- **Hydro-Quebec’s IREQ / Bellore (60~80C)
- Apple (IPS)
- Seeo Inc. (Bosch) 2007-2018
- QuantumScape (2025)
- SolidEnergy (2025)
- EMBatt (2025) *
- Bosch
- Solid Power (2026)
- Sakti3 (2015-2018)
- PLG **
- Ceramic thin film battery
- Solid polymer battery
- Ceramic thick film battery (Oxide ELT)
- Ceramic thick film battery (Sulfide ELT)

**"** BiPolar SSB (can be series)
***"** Advanced BiPolar(series and parallel)- BiPolar+ **

- Samsung SDI
- Panasonic (2025-2030)/S
- Hitachi Zosen
- Solid Power (2026)
- Ionic Material
- STMicroelectronics
Global SSB MP Progress

PLG’s SSB MP progress leading industry over 4~10 years

MP Schedule
ProLogium @2021
Japanese@2025~2030
US/Euro @2025~2026

US Competitors @2019
Japanese Competitors @2019

Basic Tech. Development
Material/system selection 5 years

RD/Sample Line
Initial process design 4 years

Test/ Pilot Run
<500MWh 3 years

Mass Production
1GWh 2~3 years

TOYOTA@2022
1. Lithium Ceramic Battery
- Solid state oxide electrolyte
  - Ultra safe
  - High energy density
  - Wide operation temp./ pressure.
  - Fast charging capability
  - Excellent heat dissipation

2. Multi Axis BiPolar+
- Based on SSB advantages
  - Series and parallel inside cell
  - Low inner resistance/ low heat production
  - Simplify cooling/ mechanism/BMS
  - Assembly efficiency increased by 29%~56.5% to 75%
    (cylindrical 32%; pouch 46%; prismatic 53%)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Al Foil (Current Collector)</td>
<td></td>
</tr>
<tr>
<td>Cathode</td>
<td></td>
</tr>
<tr>
<td>Solid State Lithium Ceramic Electrolyte</td>
<td></td>
</tr>
<tr>
<td>No Explosion</td>
<td>No Leak</td>
</tr>
<tr>
<td>Anode</td>
<td></td>
</tr>
<tr>
<td>Cu Foil (Current Collector)</td>
<td></td>
</tr>
</tbody>
</table>
3 breakthrough technologies to fix initial weakness of oxide ELT
Increase electrical performance to liquid level, even better

Ceramion®
Provide Safety
Increase Conductivity

Microcell®
Solve Brittle Issue
Make RTR Possible

Logithium®
Create Excellent Heat Dissipation Ability

Conductivity
Stability
Feasibility

Conductivity
Stability
Feasibility

Radiating rapidly and directly

Al Foil (Current Collector)
Cathode
Solid Ceramic Electrolyte
Anode
Cu Foil (Current Collector)

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Multi Axis BiPolar+

PLG Core Tech.

- **BiPolar+®**
  - Inner Series/Parallel
  - Decrease Resistance
  - Increase Assembly Efficiency

- **S-Inlay®**
  - Stacking to increase energy
  - Enhance Cooling Efficiency
  - Improve Safety® High Voltage

- **Logi-Pack®**
  - Embedded detection
  - Simplify BMS
  - Enhance Active Current Balance

3 innovational package tech. to simplify mechanism, cooling and BMS
Increase pack assembly efficiency
PLG Dual Core Tech. Advantages

- Ultra Safe
- High Energy Density
- Wide Operation Widow
- Good Fast Charge Ability
- Long Cycle Life (Calendar Life)

LCB

- High Pack Energy Density
- Lower Pack Total Cost

MAB

Solve EV Downsides:

- Poor Safety
- Too Long to Charge
- Short Battery Life
- Short Driving Distance
- Price too High

Statista
<Most import factors when buying EV>
1. Ultra Safe

LCB adopts solid-state ceramic electrolyte, so there is no fire and no explosion even it’s damaged, folded, punched, penetrated, or abnormal charged.

<table>
<thead>
<tr>
<th>Thermal Runaway Point</th>
<th>Solid State</th>
<th>Liquid Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LCB</td>
<td>T Company</td>
</tr>
<tr>
<td></td>
<td></td>
<td>130°C (No Explosion)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C Company</td>
</tr>
<tr>
<td></td>
<td></td>
<td>130°C (No Explosion)</td>
</tr>
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<td></td>
<td>L Company</td>
</tr>
<tr>
<td></td>
<td></td>
<td>130°C (No Explosion)</td>
</tr>
</tbody>
</table>


## LCB Advantage

### 1. Ultra Safe: International Safety Regulation

Note: lower Hazard Level represent higher stability

*liquid battery cannot pass original condition, condition downgrade

<table>
<thead>
<tr>
<th>Items</th>
<th>PLG</th>
<th>European EV Maker 1</th>
<th>European EV Maker 2</th>
<th>GBT-31485</th>
<th>UL1642</th>
</tr>
</thead>
</table>
| Nail            | Hazard Level 2 (RT;3mm;8cm/sec.) | **PLG**: Hazard Level 2  
Lib : Hazard Level 4-5 (RT;3mm;8cm/sec.) | **PLG**: Hazard Level 2-3  
Lib : Hazard Level 4-5 (60°C) | **PLG**: PASS  
Lib : Failed  
Before 2017 RT;5~8mm;25cm/sec.  
After 2017: Test Canceled* | **PLG**: PASS  |
| Over Charge     | Hazard Level 2 (3C;12V;24hrs) | **PLG**: Hazard Level 3  
Lib : Hazard Level 4-5 (7C ’5V @ 25°C) | **PLG**: Hazard Level 2  
Lib : Hazard Level 4-5 (5C,10V @ 60°C) | **PLG**: PASS  
Lib : Failed  
Before 2018: 1C CC Charge to 1.5 times cut-off voltage or 1 hr  
After 2018:1C CC Charge to 1.1 times cut-off voltage or 115% SOC* | **PLG**: PASS  |
| Thermal         | Hazard Level 2 (5°C/min;130°C*10min) | **PLG**: Hazard Level 3  
Lib : Hazard Level 4-5 (25~200°C, SOC100%) | **PLG**: Hazard Level 3  
Lib : Hazard Level 4-5 (25~200°C, SOC100%) | **PLG**: PASS  
(5°C/min;130°C*10min) | **PLG**: PASS  |

* liquid battery cannot pass original condition, condition downgrade
<table>
<thead>
<tr>
<th>Hazard Level</th>
<th>Description</th>
<th>Classification Criteria &amp; Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No effect</td>
<td>No effect. No loss of functionality.</td>
</tr>
<tr>
<td>1</td>
<td>Passive protection activated</td>
<td>No defect; no leakage; no venting, fire, or flame; no rupture; no explosion; no exothermic reaction or thermal runaway. Cell reversibly damaged. Repair of protection device needed.</td>
</tr>
<tr>
<td>2</td>
<td>Defect/Damage</td>
<td>No leakage; no venting, fire, or flame; no rupture; no explosion; no exothermic reaction or thermal runaway. Cell irreversibly damaged. Repair needed.</td>
</tr>
<tr>
<td>3</td>
<td>Leakage</td>
<td>No venting, fire, or flame; no rupture; no explosion. Weight loss &lt; 50 % of electrolyte weight (electrolyte = solvent + salt).</td>
</tr>
<tr>
<td>4</td>
<td>Venting</td>
<td>No fire or flame; no rupture; no explosion. Weight loss ≥ 50 % of electrolyte weight (electrolyte = solvent + salt).</td>
</tr>
<tr>
<td>5</td>
<td>Fire or Flame</td>
<td>No rupture; no explosion (i.e., no flying parts).</td>
</tr>
<tr>
<td>6</td>
<td>Rupture</td>
<td>No explosion, but flying parts of the active mass.</td>
</tr>
<tr>
<td>7</td>
<td>Explosion</td>
<td>Explosion (i.e., disintegration of the cell).</td>
</tr>
</tbody>
</table>
LCB Advantage

1. Ultra Safe

PLG’s SSB still stable over critical safety test conditions

**<Physical> 60°C Penetrate**

<table>
<thead>
<tr>
<th>Test date</th>
<th>Mass Loss</th>
<th>EUCAR Hazard Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>04/11/2016</td>
<td>0 g</td>
<td>2 - 3</td>
</tr>
</tbody>
</table>

Comments:
- Cell irreversible damaged, no measureable weight loss, but smoke emission → EHL = 2 - 3
- Maximum cell temperature = 154 °C

**<Electrical> 60°C Over Charge**

<table>
<thead>
<tr>
<th>Cell IDs</th>
<th>Test date</th>
<th>EUCAR Hazard Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLG-AP410G-X0-008</td>
<td>16/11/2016</td>
<td>2</td>
</tr>
</tbody>
</table>

Comments:
- No Fire, No Rupture, No Electrolyte loss → EHL = 2

*5C/10V
PLG’s SSB still stable over critical safety test conditions

1. Ultra Safe

No Short Circuit Point
Liquid PE/PP Short Circuit Point@120~140°C

<High Temp.> 280°C Storage

<High Temp.> 200°C Storage

Criteria
25~200°C, SOC100%

EUCAR Hazard Level
3 or 4

Oven Test

Comments
Cell swelling visible. Impact on safety test with cell tensed up is open.

Thermal Stability

Criteria
EUCAR Hazard Level
25~200°C, SOC100%
3 or 4

Test date
17-18/11/2016

EUCAR Hazard Level
3 - 4

Comments
No Fire, No Rupture, weight loss = Cell opening at “Cell Top” temperature of 151°C and “Cell Bottom” temperature of 101°C (cell inflation and contracting visible on video footage)
- exothermal reaction at 185°C - EHL = 3 - 4
The high stability and mechanical strength of ceramic electrolytes makes LCB resistant to extreme pressure/temperature conditions.

<table>
<thead>
<tr>
<th>Temperature/Pressure</th>
<th>LCB Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>High/ Low Temp. X High/ Low Pressure = Unlimited Applications</td>
<td></td>
</tr>
<tr>
<td>-40°C Discharge - Polar/Mine/Freeze</td>
<td></td>
</tr>
<tr>
<td>115°C Discharge - Stove/Fire</td>
<td></td>
</tr>
<tr>
<td>10⁻⁸ Torr - Vacuum/ Space</td>
<td></td>
</tr>
<tr>
<td>680 ATM - 6,790M under water</td>
<td></td>
</tr>
</tbody>
</table>
## 2. Wider Operation Window: Temperature

<table>
<thead>
<tr>
<th>Conditions</th>
<th>PLG SSB</th>
<th>Polymer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation Window (Charge)</td>
<td>-20~85°C</td>
<td>0-45°C</td>
</tr>
<tr>
<td>Operation Window (Discharge)</td>
<td>-40<del>85°C @4.2V-3V 85</del>115°C @3.9V-3V</td>
<td>-20~60°C</td>
</tr>
<tr>
<td>Storage</td>
<td>-65°C (3 months)~85°C (14 days) @4.2V or -65°C (3 months)~105°C (14 days) @3.9V 115°C (7 days) @3.9V</td>
<td>-20~60°C</td>
</tr>
</tbody>
</table>

### Graphs

- **Charge Temp.**
  - PLG: 85°C
  - Others: 45°C
- **Discharge Temp.**
  - PLG: 115°C
  - Others: 60°C
- **Storage Temp.**
  - PLG: 115°C
  - Others: -65°C

---

**PLG SSB**

**Polymer**

**Others**
LCB Advantage

3. Fast Charge Ability

By improving conductivity, LCB’s fast charging capability is increased year by year.

Progress in Fast Charging

Surpassing Cylindrical LiB
4. Long Lifetime

Cycle life and calendar life are both important factors when estimating battery lifetime.
PLG SSB cycle life was better than liquid type battery, 80% capacity after 1,800 cycle.
4. Long Lifetime: Fast Charging Tolerance

Even cycle under critical fast charging condition, LCB still remain excellent fast charging ability.

**Fast Charge Cycle**

**2C/4C Fast Charge Cycle**

【ProLogium LCB】
1. 2C fast charge：currently finished 100th cycle
2. 4C fast charge：currently finished 140th cycle

【Liquid type lithium battery】
No cycle test data under fast charging
4. Long Lifetime: Calendar Life

Test under 60°C/60 days to simulate 2 years usage, LCB retention capacity is 15% higher than liquid battery and no DCIR increment. Maximum capacity usage due to high consistency between cells caused by bare internal resistance differences. Longer pack life time to reduce maintenance fee of customers.

60°C Cycle Test

<table>
<thead>
<tr>
<th>Retention (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLG PLCB (N=1)</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>95</td>
</tr>
<tr>
<td>90</td>
</tr>
<tr>
<td>85</td>
</tr>
<tr>
<td>80</td>
</tr>
<tr>
<td>75</td>
</tr>
<tr>
<td>70</td>
</tr>
</tbody>
</table>

15% more than 18650

<table>
<thead>
<tr>
<th>DCIR Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLG PLCB (N=1)</td>
</tr>
<tr>
<td>1.0</td>
</tr>
<tr>
<td>2.0</td>
</tr>
<tr>
<td>3.0</td>
</tr>
<tr>
<td>Days</td>
</tr>
</tbody>
</table>

18650 increase 200%

PLCB 1.0
MAB Advantage

1. High Energy Density Battery Pack

Increase both cell energy density and pack assembly efficiency to maximum pack energy density

High E.D. Cell \times \text{High Assembly Efficiency} = \text{High E.D. Pack} = \text{Driving Distance Equal to Fuel Car}
MAB Advantage

1. High E.D. Pack: Cell Level

Cell Energy Density Roadmap

- **Wh/L**
- **Wh/kg**

R&D sample

- Toyota @2030: 800Wh/L
- Toyota @2022: 450Wh/L

**Anode**
- Gr.
- SiOx (14%=>100%)
- Li-metal/ Pure Si

**Cathode**
- NMC622
- NMC811
- HNCA/HNMC

Low E.D. /Safe

High E.D. /Dangerous
MAB Advantage

1. High E.D. Pack: Assembly Efficiency

MAB assembly efficiency reaches 75%, which is 29%~56.5% higher than traditional battery by simplifying mechanism, cooling system and BMS.

Source: Nikkei Automotive 2018.09
1. High E.D. Pack: E.D. Road MAP (R&D sample)

**Cell** ROADMAP (Wh/kg)

<table>
<thead>
<tr>
<th>Year</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>China Standard:</td>
<td>2025</td>
<td>400 Wh/kg</td>
<td>2020</td>
<td>300 Wh/kg</td>
<td>2018</td>
<td>200</td>
<td>240</td>
<td>270</td>
</tr>
</tbody>
</table>

**Pack** ROADMAP (Wh/kg)

<table>
<thead>
<tr>
<th>Year</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>China Standard:</td>
<td>2025</td>
<td>300 Wh/kg</td>
<td>2020</td>
<td>220 Wh/kg</td>
<td>2018</td>
<td>170</td>
<td>204</td>
<td>230</td>
</tr>
</tbody>
</table>

**Cell** ROADMAP (Wh/L)

<table>
<thead>
<tr>
<th>Year</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tesla Model 3 Cell:</td>
<td>715 Wh/L</td>
<td>TOYOTA 2022 target: 450 Wh/L</td>
<td>2018</td>
<td>500</td>
<td>600</td>
<td>680</td>
<td>750</td>
<td>816</td>
</tr>
</tbody>
</table>

**Pack** ROADMAP (Wh/L)

<table>
<thead>
<tr>
<th>Year</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOYOTA 2022 target:</td>
<td>338 Wh/L</td>
<td>Tesla Model 3 Pack: 232 Wh/L</td>
<td>2018</td>
<td>375</td>
<td>450</td>
<td>510</td>
<td>563</td>
<td>612</td>
</tr>
</tbody>
</table>
## 1. High E.D. Pack: Best Among All

### Pack Energy Density Comparison

<table>
<thead>
<tr>
<th>Pack Type</th>
<th>Energy Density (Wh/L)</th>
<th>Specific Energy (Wh/Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CYLINDRICAL</td>
<td>232 Wh/L</td>
<td>166 Wh/kg</td>
</tr>
<tr>
<td>POUCH</td>
<td>276 Wh/L</td>
<td>189 Wh/kg</td>
</tr>
<tr>
<td>PRISMATIC</td>
<td>275 Wh/L</td>
<td>185 Wh/kg</td>
</tr>
<tr>
<td>MAB</td>
<td>523 Wh/L</td>
<td>238 Wh/kg</td>
</tr>
</tbody>
</table>

### 2020 MP

<table>
<thead>
<tr>
<th>LIB</th>
<th>Cell</th>
<th>Assembly Efficiency (Volume)</th>
<th>Pack</th>
<th>Cell</th>
<th>Assembly Efficiency (Weight)</th>
<th>Pack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylindrical</td>
<td>715</td>
<td>32%</td>
<td>232</td>
<td>250</td>
<td>66%</td>
<td>166</td>
</tr>
<tr>
<td>Pouch</td>
<td>600</td>
<td>46%</td>
<td>276</td>
<td>278</td>
<td>68%</td>
<td>189</td>
</tr>
<tr>
<td>Prismatic</td>
<td>520</td>
<td>53%</td>
<td>275</td>
<td>265</td>
<td>70%</td>
<td>185</td>
</tr>
</tbody>
</table>

### PLG

<table>
<thead>
<tr>
<th>Pack</th>
<th>Energy Density (Wh/L)</th>
<th>Specific Energy (Wh/Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAB Pack</td>
<td>600</td>
<td>75%</td>
</tr>
</tbody>
</table>
MAB Advantage

2. Lower Total Pack Cost

Only 70% cost, 50% volume and 70% weight of traditional pack.
Commercialization

Accumulated Revenue
USD 5,170,967
(till 2018)

2014
Accessories

2015
Smart Card
Wearable

2017
IOT/Industry
Special Application
PLG Target Market

Vehicle
- EV / Rail / Ship

Consumer
- E-bike / Portable / Wearable / IoT

Industry
- Device / IIoT / Vehicle / ESS
Vehicle

Commercial UGV

Consumer Vehicle

Drone/AUV

Rail/Ship
Consumer & Professional

Wearable Device

**Power Vest**

**Heating Wrist Band**

**Smart Helmet**

**Heating Insole**
Portable Device

- Rugged Tablet
- Medical Devices
- Charging Device
- Smart Device
Consumer & Professional

Energy Storage System

UPS

Renewable Energy

Commercial ESS

Home ESS
EV : MAB pack

- Ultra safe
- High energy density
- MAB Technology
- High assembly efficiency

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Voltage (V)</th>
<th>Capacity (Ah)</th>
<th>Dimension (mm)</th>
<th>Pack Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAB Cell</td>
<td>43.8V</td>
<td>43Ah</td>
<td>220.5x750x150</td>
<td>1.8 kWh</td>
</tr>
<tr>
<td>MAB Module</td>
<td>43.8V</td>
<td>215Ah</td>
<td>220.5x750x150</td>
<td>9.4 kWh X n</td>
</tr>
<tr>
<td>MAB Pack</td>
<td></td>
<td></td>
<td></td>
<td>customized</td>
</tr>
</tbody>
</table>

* 2018 MP Spec
## Vehicle

### E-Scooter

- Ultra safe
- High energy density
- High assembly efficiency

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Voltage (V)</th>
<th>Capacity (Ah)</th>
<th>Dimension (mm)</th>
<th>Pack Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLCB133218</td>
<td>48</td>
<td>42</td>
<td>customized</td>
<td>2kWh</td>
</tr>
</tbody>
</table>

2018 MP Spec
Rolling Stock & Ship

- Ultra safe
- High energy density
- MAB Technology
- High assembly efficiency

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Voltage (V)</th>
<th>Capacity (Ah)</th>
<th>Dimension (mm)</th>
<th>Pack Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLCB133218 (NSNP)</td>
<td>120V</td>
<td>3000Ah</td>
<td>Customized</td>
<td>360 kWh</td>
</tr>
</tbody>
</table>

* 2018 MP Spec
### Heating Insole
- Ultra safe
- Ultra thin, flexible
- Good temp. durability

<table>
<thead>
<tr>
<th>Cell Spec</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension/mm</td>
<td>42*88</td>
</tr>
<tr>
<td>Capacity</td>
<td>1450mAh</td>
</tr>
<tr>
<td>Operation Voltage</td>
<td>4.35-2.75V</td>
</tr>
<tr>
<td>Thickness/mm</td>
<td>6.3mm</td>
</tr>
</tbody>
</table>

* 2018 MP

### Smart Helmet
- Ultra safe
- Ultra thin, flexible
- Good temp. durability

<table>
<thead>
<tr>
<th>Cell Spec</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension/mm</td>
<td>52*55</td>
</tr>
<tr>
<td>Capacity</td>
<td>770mAh</td>
</tr>
<tr>
<td>Operation Voltage</td>
<td>4.4V-3.0V</td>
</tr>
<tr>
<td>Thickness/mm</td>
<td>4.8mm</td>
</tr>
</tbody>
</table>

* 2018 MP

### Wrist Band
- Ultra safe
- Ultra thin, flexible
- Good temp. durability

<table>
<thead>
<tr>
<th>Cell Spec</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension/mm</td>
<td>107*163</td>
</tr>
<tr>
<td>Capacity</td>
<td>1880mAh</td>
</tr>
<tr>
<td>Operation Voltage</td>
<td>4.35-2.75V</td>
</tr>
<tr>
<td>Thickness/mm</td>
<td>1.72mm</td>
</tr>
</tbody>
</table>

* 2018 MP
**Portable Device**

### Power Bag
- Ultra safe
- Ultra Thin

<table>
<thead>
<tr>
<th>Cell Spec</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension:mm</td>
<td>133*218(mm)</td>
</tr>
<tr>
<td>Capacity</td>
<td>3550mAh</td>
</tr>
<tr>
<td>Operation Voltage</td>
<td>4.4V-3.0V</td>
</tr>
<tr>
<td>Thickness/mm</td>
<td>1.5mm</td>
</tr>
</tbody>
</table>

* 2018 MP

### iphoneX Case
- Ultra safe
- Ultra Thin

<table>
<thead>
<tr>
<th>Cell Spec</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension/mm</td>
<td>60*105</td>
</tr>
<tr>
<td>Capacity</td>
<td>1500mAh</td>
</tr>
<tr>
<td>Operation Voltage</td>
<td>3.75V</td>
</tr>
<tr>
<td>Thickness/mm</td>
<td>3.3mm</td>
</tr>
</tbody>
</table>

* 2018 MP

### Power Leaf Tag
- Ultra safe
- Ultra Thin

<table>
<thead>
<tr>
<th>Cell Spec</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension/mm</td>
<td>51*76</td>
</tr>
<tr>
<td>Capacity</td>
<td>700mAh</td>
</tr>
<tr>
<td>Operation Voltage</td>
<td>3.75V</td>
</tr>
<tr>
<td>Thickness/mm</td>
<td>2.8mm</td>
</tr>
</tbody>
</table>

* 2018 MP
### Portable Device

#### E-Bike
- Ultra safe
- High E.D.
- High assembly efficiency

<table>
<thead>
<tr>
<th>Cell Spec</th>
<th>133*218</th>
<th>15 Ah</th>
<th>36 V</th>
<th>customized</th>
</tr>
</thead>
</table>

* 2020 MP

#### E-Book
- Ultra safe
- Large footprint
- Flexible, ultrathin (0.43mm)

<table>
<thead>
<tr>
<th>Cell Spec</th>
<th>210*160</th>
<th>1900mAh</th>
<th>4.35V-2.75 V</th>
<th>0.9 mm(2P)</th>
</tr>
</thead>
</table>

* 2018 MP

#### Cell Phone
- Ultra safe
- 7.2V high voltage BLCD
- Good stability

<table>
<thead>
<tr>
<th>Cell Spec</th>
<th>60*105</th>
<th>2200mAh</th>
<th>7.2V</th>
<th>4.3mm</th>
</tr>
</thead>
</table>

* 2021 MP
**Smart Card**

- Ultra thin, flexible
- Good pressure durability

<table>
<thead>
<tr>
<th>Cell Spec</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimension/ mm</strong></td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
</tr>
<tr>
<td><strong>Operation Voltage</strong></td>
</tr>
<tr>
<td><strong>Thickness/ mm</strong></td>
</tr>
</tbody>
</table>

* 2018 MP

---

**Tracker**

- Ultra safe
- Ultra thin
- Long cycle life

<table>
<thead>
<tr>
<th>Cell Spec</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimension/ mm</strong></td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
</tr>
<tr>
<td><strong>Operation Voltage</strong></td>
</tr>
<tr>
<td><strong>Thickness/ mm</strong></td>
</tr>
</tbody>
</table>

* 2018 MP

---

**Thermometer**

- Ultra safe
- Ultra thin, flexible
- Good temp. durability

<table>
<thead>
<tr>
<th>Cell Spec</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimension/ mm</strong></td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
</tr>
<tr>
<td><strong>Operation Voltage</strong></td>
</tr>
</tbody>
</table>

* 2018 MP
**Industry Wearable/ Devices**

**Rugged Tablet**
- Ultra safe
- High energy density
- Wider operation window
- Good temp. stability (105°C discharge)

<table>
<thead>
<tr>
<th>Cell Spec</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension/ mm</td>
<td>133x 218</td>
</tr>
<tr>
<td>Capacity</td>
<td>5.4Ah</td>
</tr>
<tr>
<td>Operation Voltage</td>
<td>4.35V-2.75 V</td>
</tr>
<tr>
<td>Thickness/ mm</td>
<td>2.1</td>
</tr>
</tbody>
</table>

* 2019 MP

**Power Vest**
- Ultra safe
- Ultra thin
- Good temp. durability

<table>
<thead>
<tr>
<th>Cell Spec</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension/ mm</td>
<td>107*163</td>
</tr>
<tr>
<td>Capacity</td>
<td>2.82 Ah</td>
</tr>
<tr>
<td>Operation Voltage</td>
<td>4.35V-2.75 V</td>
</tr>
<tr>
<td>Thickness/ mm</td>
<td>2.8</td>
</tr>
</tbody>
</table>

* 2018 MP

**Medical Devices**
- Ultra safe
- Ultra thin
- Good temp. durability

<table>
<thead>
<tr>
<th>Cell Spec</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension/ mm</td>
<td>240*105</td>
</tr>
<tr>
<td>Capacity</td>
<td>10 Ah</td>
</tr>
<tr>
<td>Operation Voltage</td>
<td>4.35V-2.75 V</td>
</tr>
<tr>
<td>Thickness/ mm</td>
<td>4.5</td>
</tr>
</tbody>
</table>

* 2019 MP
Industry/ Special Application

IOV

**T-Box**
- Ultra safe
- High energy density
- Storage 14 days @ 85°C (swelling < 10%)
- Wider operation window
- Good temp. stability (DCH 2C > 90% @ 85°C)

**Cell Spec**

<table>
<thead>
<tr>
<th>Dimension/mm</th>
<th>52*55</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>600mAh</td>
</tr>
<tr>
<td>Operation Voltage</td>
<td>4.2V-3.0V</td>
</tr>
<tr>
<td>Thickness/mm</td>
<td>4.8</td>
</tr>
</tbody>
</table>

* 2018 MP

**ELD**
- Ultra safe
- High energy density
- Storage 7 days @ 115°C (swelling < 10%)
- Wider operation window
- Good temp. stability (DCH 2A > 81%, 16min @ 115°C)

**Cell Spec**

<table>
<thead>
<tr>
<th>Dimension/mm</th>
<th>42*88</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>600 mAh</td>
</tr>
<tr>
<td>Operation Voltage</td>
<td>3.9V-3.0V</td>
</tr>
<tr>
<td>Thickness/mm</td>
<td>6.3</td>
</tr>
</tbody>
</table>

* 2018 MP

**Sensor**
- Ultra safe
- Flexible
- Good temp. stability (85°C discharge)
- Good low pressure durability (10^*torr@85°C)

**Cell Spec**

<table>
<thead>
<tr>
<th>Dimension/mm</th>
<th>46*46</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>45 mAh</td>
</tr>
<tr>
<td>Operation Voltage</td>
<td>4.35V-2.75V</td>
</tr>
<tr>
<td>Thickness/mm</td>
<td>0.43</td>
</tr>
</tbody>
</table>

* 2018 MP
Industry/ Special Application

Commercial Vehicle

- Ultra safe
- Good temp. stability
  (40°C ~ 90°C discharge)
- Good fast charge ability
- High Pack energy density (BLCB)

<table>
<thead>
<tr>
<th>System</th>
<th>Model Name</th>
<th>Voltage (V)</th>
<th>Capacity (Ah)</th>
<th>Dimension (mm)</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell</td>
<td>PLCB133218 (10P)</td>
<td>3.6</td>
<td>11</td>
<td>133 x 218 x 3.5</td>
<td>39.6 Wh</td>
</tr>
<tr>
<td>Pack</td>
<td>13S8P</td>
<td>46.8</td>
<td>88</td>
<td>1064 x 218 x 45.5</td>
<td>4.1 kWh</td>
</tr>
</tbody>
</table>

* 2019 MP
Vehicle

- Ultra safe
- High energy density (BLCB)
- Good high pressure durability
  (680 ATM = 6790 m under water)
- Good stability @ low temp.
  (-10°C charge/discharge)

### AUV System

<table>
<thead>
<tr>
<th>System</th>
<th>Model Name</th>
<th>Voltage (V)</th>
<th>Capacity (Ah)</th>
<th>Dimension (mm)</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell</td>
<td>PLCB133218</td>
<td>3.6</td>
<td>11</td>
<td>133 x 218 x 3.5</td>
<td>39.6 Wh</td>
</tr>
<tr>
<td>Pack</td>
<td>8S1P</td>
<td>28.8</td>
<td>11</td>
<td>133 x 218 x 28</td>
<td>317 Wh</td>
</tr>
</tbody>
</table>

*2019 MP
## Industry/ Special Application

### Vehicle

#### Drone

<table>
<thead>
<tr>
<th>Items</th>
<th>Position</th>
<th>Model Name</th>
<th>Voltage(V)</th>
<th>Capacity(Ah)</th>
<th>Dimension(mm)</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control System</td>
<td>Wings</td>
<td>FLCB210160 (4P)* N * 2(2 Wings)</td>
<td>14.4V</td>
<td>4.6</td>
<td>210*160</td>
<td>66.2 Wh</td>
</tr>
<tr>
<td>Main Power</td>
<td>Body</td>
<td>PLCB060105</td>
<td>17.9V</td>
<td>15.6</td>
<td>133*218</td>
<td>279.24 Wh</td>
</tr>
</tbody>
</table>

* Ultra safe
* Flexible
* Wide operation window
* Balanced weight

* 2020 MP
Industry/ Special Application

ESS

### Commercial ESS

<table>
<thead>
<tr>
<th>Products</th>
<th>System</th>
<th>Model</th>
<th>Voltage (V)</th>
<th>Capacity (Ah)</th>
<th>Dimension (mm)</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server Backup Battery</td>
<td>PLCB133218</td>
<td>3.75</td>
<td>8.3</td>
<td>133 x 218 x 3.7</td>
<td>31Wh</td>
<td>PLCB133218</td>
</tr>
<tr>
<td></td>
<td>13S1P</td>
<td>48</td>
<td>8.3</td>
<td>133 x 218 x 48.1</td>
<td>398Wh</td>
<td>13S1P</td>
</tr>
<tr>
<td>Data Center Backup Battery</td>
<td>PLCB133218</td>
<td>3.75</td>
<td>8.3</td>
<td>133 x 218 x 3.7</td>
<td>31Wh</td>
<td>PLCB133218</td>
</tr>
<tr>
<td></td>
<td>PLCB133218</td>
<td>270</td>
<td>838</td>
<td>Customized</td>
<td>226KWh</td>
<td>PLCB133218</td>
</tr>
<tr>
<td>Renewable Energy</td>
<td>PLCB133218</td>
<td>3.75</td>
<td>8.3</td>
<td>133 x 218 x 3.7</td>
<td>31Wh</td>
<td>PLCB133218</td>
</tr>
<tr>
<td></td>
<td>13S3P</td>
<td>48</td>
<td>24.9</td>
<td>399 x 218 x 48.1</td>
<td>1.2kWh</td>
<td>13S3P</td>
</tr>
</tbody>
</table>

* 2018 MP

- Ultra safe
- Long calendar life
- High discharge rate @ high temp.
- High energy density
- Wider operation: -40°C ~ 105°C discharge