REPORT OUTLINE

I. xEV Market Trends

1. Overview
   - Market Drivers
   - Recent EV-Market Boosters
   - Until Tesla, most automakers had introduced subcompact and city EVs with a 70- to 90-mile range
   - Battery-EV Main Development and Direction
   - PHEV Main Development and Direction
   - Strong HEV Main Development and Direction
   - Mild to Advanced Micro-HEV (MHEV) Main Development and Direction
   - Powertrain Electrification and CO2 Emission Impact
   - xEV Market Development by Category

2. Vehicle Markets by Region
   - Current Chinese xEV Market Trends, Market Drivers – Government
   - Current Chinese xEV Market Trends, Market Drivers – Automakers
   - Chinese e-Bus Industry
   - Chinese xEVs – The Bottom Line
   - Current European xEV Market Trends – Market Drivers
   - Current European xEV Market Trends – EVs
   - Current European xEV Market Trends – PHEVs
   - Current European xEV Market Trends – Strong Hybrids (HEVs)
   - Current European xEV Market Trends – Mild Hybrids (MHEVs)
   - Current European xEV Market Trends – Micro Hybrids (µHEVs)
• Current U.S. xEV Market Trends – Market Drivers
• Current U.S. xEV Market Trends – EVs
• Current U.S. xEV Market Trends – PHEVs
• Current U.S. xEV Market Trends – Strong HEVs
• Current U.S. xEV Market Trends – MHEVs
• U.S. HEV Sales
• Current Japanese xEV Market Trends – Hybrids
• Current Japanese xEV Market Trends – PHEVs/EVs
• Current xEV Market Trends – Rest of the World (ROW)

3. Vehicle Market Forecast
• HEV Market by Vehicle Producer 2010 – 2020
• HEV Market by Vehicle Producer 2010 – 2020, Excluding Toyota and Honda
• HEV Market by Hybrid Category
• HEV Market by World Region 2009 to 2020
• EV Market Forecast
• EV Market Forecast – Excluding Chinese Automakers
• PHEV Market by Producer
• EV Market (Forecast) by World Region
• PHEV Market Forecast by World Region

4. Directions of Individual Automakers
• xEV Efforts by Automakers—Asia
• xEV Efforts by Automakers—U.S. / Europe
• xEV Efforts by Automakers—Europe
• Toyota / Lexus
• 2001-17 Toyota HEV Family
II. Lithium-Ion Battery Technology for xEVs

1. Key Design Parameters

- xEV Battery Technology Overview
- Historical xEV Battery Development
- Cathode Chemistry
- Electrolytes
- Cell Casing
2. **Mild and Strong Hybrid Batteries**

- Batteries for Strong Hybrids
- 2001-17 Toyota HEV NiMH Battery Pack Parameters
- HEV Li-Ion Cell Current Design Matrix
- Li-Ion Prismatic Metal Can Cells Involved in Production HEVs
- Li-Ion HEV Cell Materials Cost
- Li-Ion HEV 5-Ah Cell Price
- HEV Battery Price Trends
- Li-Ion HEV: Key Cost Components
- Micro-2 Hybrids: Energy-Storage Solutions
- Micro-2 Hybrids: Energy-Storage Solutions (2)
- Micro-2 Hybrids: Energy-Storage Solutions (3)
- 48V Mild Hybrids – Battery Requirements and Selection
- Low-Voltage Hybrid Li-Ion Design

3. **EV & PHEV Battery Technology and Cost**

- Battery Pack Capacity for PHEVs
- PHEV Battery Pack – Specific Energy
- PHEV Battery Pack – Capacity vs. Launch Year
- PHEV Battery Pack – Specific Energy vs. Launch Year
- PHEV Cell and Pack – 2017 Market
- GM Volt 2/Volt 1 Battery Comparison
- PHEV-2 Roadmap
- Cells Delivering 600Wh/liter are Being Qualified
- VW’s Aggressive Technology Roadmap – Very Challenging Beyond 700Wh/liter
- Where is the improvement in energy density coming from?
• Mercedes PHEV Battery-Pack Parameters
• EV & PHEV Battery Life
• Li-Ion Cells Employed in EVs 2008-2016
• Key Characteristics of EV Cells Utilized in EV Packs H1-2017
• EV Pack Key Characteristics since 1996
• Energy Density Evolution of Cylindrical Cells
• Specific Energy of EV Battery Packs
• Battery Packs for EVs vs. Launch Year
• Battery Packs for EVs – Specific Energy vs. Launch Year
• Tesla Battery Capacity versus Driven km (as published by Tesla Drivers Club)
• Li-Ion Battery Safety
• Safety at Module and Pack Levels
• Safety: Key Issues
• Safety Enhancement and its Cost
• xEV Battery Power and Energy Level vs. Applications
• xEV Battery Energy Density vs. Power Level
• 37-Ah PHEV Cell Materials Cost
• 37-Ah PHEV Cell Price
• Cell Price for a 44 Ah Prismatic PHEV cell (2020)
• PHEV Battery Price Trends
• 56-Ah EV Pouch Cell Materials Cost
• 56-Ah EV Pouch Cell Price
• 3.4-Ah 18650 Cell Materials Cost
• 3.4-Ah 18650 Cell Price 2016
• 21700 Cell Materials Cost – 2020
• 21700 Cell Price 2020
• Nickel Metal Pricing $US/metric ton
• Cobalt Pricing $US/metric ton
• Lithium Pricing
• NMC Cost Estimate 2017 to 2020 Average
• EV Cell Pricing Chevy Bolt (GM)
• EV Battery Cost Estimate, 2020
• EV Battery Price Trends
• VW’s Aggressive (unrealistic) Price Target for Cells and Packs
• xEV Battery Technology Cost and Pricing

III. xEV Battery Market Forecast to 2020

1. xEV Market Overview
   • xEV Battery Market Overview
   • xEV Battery Pack Business
   • 2020 Automotive Li-Ion Battery Market
   • xEV Li-Ion Battery Market 2020

2. Mild and Strong Hybrids
   • HEV OEM – Supplier Relationships
   • HEV Battery Pack Market
   • Li-Ion HEV Battery Module Market

3. PHEVs & EVs
   • PHEV OEM – Supplier Relationships
   • PHEV Battery Cell Market by Producer (including PHEV Buses)
   • EV OEM – Supplier Relationships
   • EV Battery Cell Market by Producer
   • Combined PHEV & EV Cell Market by Producer
4. Demand for Materials
   • HEV Cell Materials Demand 2020
   • PHEV-EV Cell Materials Demand 2020
   • xEV Cell Materials Demand, 2020

IV. Technology and Market Development to 2025

1. xEV Market Development and Forecast by Region
   • EV Market Development to 2025
   • 2025 xEV Market Share Forecast by Region
   • 2025 xEV Market Forecast by Region

2. Battery Technology for 2015
   • Lithium-Ion Technology Projections for 2025
   • Beyond Lithium Ion in 2015
   • Beyond Li Ion – Which Technologies are promising?
   • Li Ion versus Li/S - Battery Requirement Spider Diagram
   • Our Projections for 2025 – EVs
   • Our Projections for 2025 – PHEVs
   • Our Projections for 2025 – Strong HEVs
   • Our Projections for 2025 – 48V Mild HEVs

3. Battery Market by xEV Category
   • Automotive Li-Ion Battery Business – 2015 Base Case
   • Automotive Li-Ion Battery Business – 2015 Aggressive Case

4. Materials Demand and Supply
   • 2025 xEV Battery Material Demand
   • Key Base Metal Demand for xEV Batteries
   • 2025 Conclusion

V. Directions of Individual Battery Makers
Panasonic
• LG Chem
• Samsung SDI
• CATL
• Chinese Market – Battery Makers
• AESC Advanced Energy Supply Corporation
• GS Yuasa Group
• SK Innovation
• Toshiba
• Hitachi Vehicle Energy
• A123 Systems
• Johnson Controls

VI. Appendix
1. Levels of Vehicle Hybridization
   • Levels of Vehicle Hybridization/Electrification
   • Key Hybrid Functions
   • Which level of electrification?
   • Micro-1 Hybrids (Stop/Start)
   • Micro-2 Hybrids
   • 48V Mild Hybrids
   • 100-140V Mild Hybrids
   • Strong Hybrids
   • Plug-in Hybrids
   • History of EV Battery Development
   • Electric Vehicles
   • Fuel-Cell Vehicles
• Heavy-Duty Vehicles

2. Lead-Acid and NiMH HEV Batteries and Ultracapacitors

• Enhanced Flooded Lead-Acid Battery Design (Exide)
• Valve-Regulated Lead Acid
• Lead Acid in Future Automotive
• EC Capacitors
• Nickel Metal Hydride HEV Cells
• Commercial Status of NiMH
• Lead Acid Producers – U.S. & Europe
• Lead Acid Producers – Japan
• NiMH producers Primearth EV Energy