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# ETC Battery and FuelCells Sweden AB

Hybrid Vehicle Batteries



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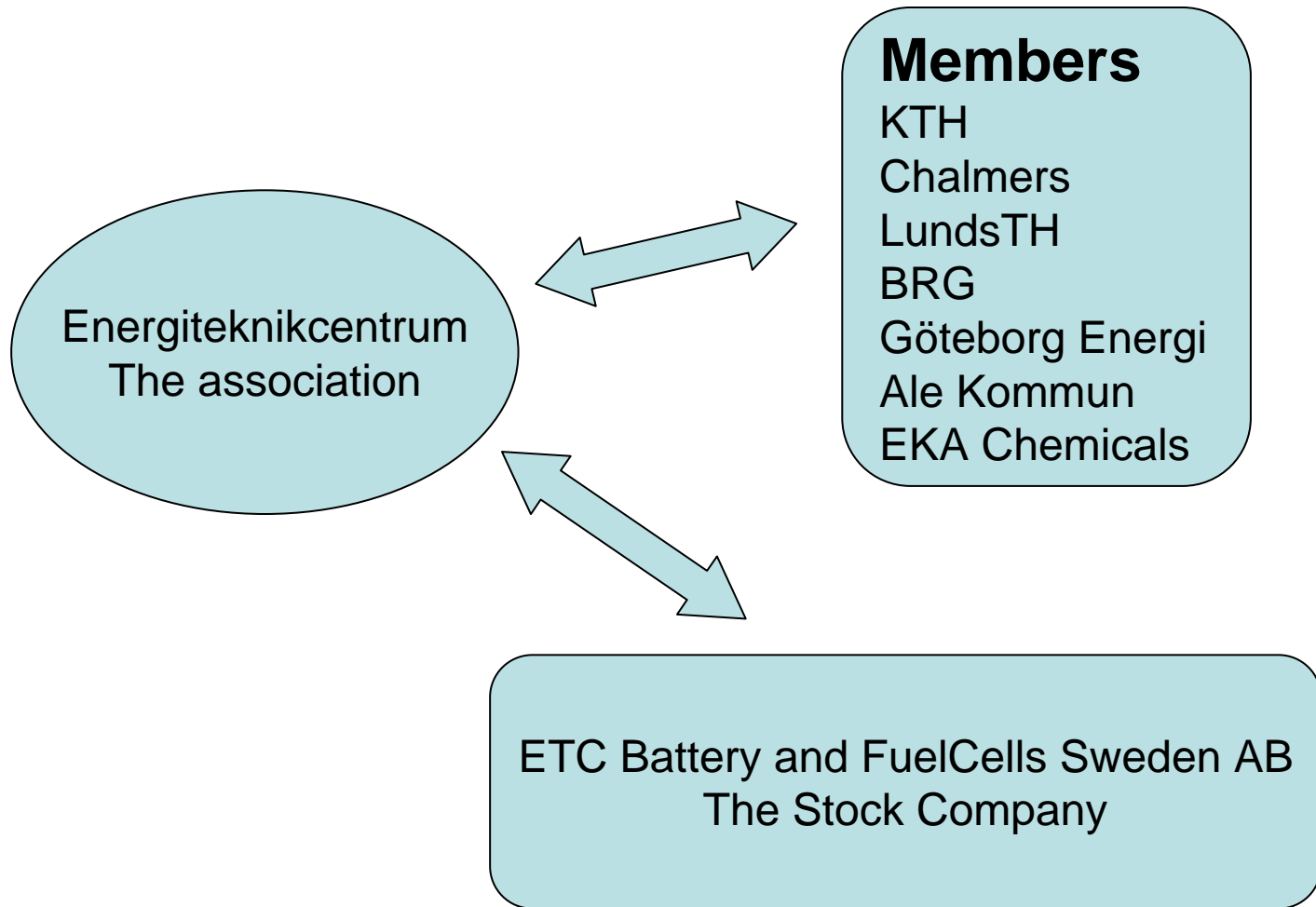


A centre to link research results into industrial products and processes within the areas of energy conversion and energy storage

The aim is to, via prototypes, link research results into production. To contribute with new business ideas and provide the industry with new technologies and methods within the field.



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Research and  
market analysis

Product  
development

Prototype and  
pilot manufacture

Series  
production



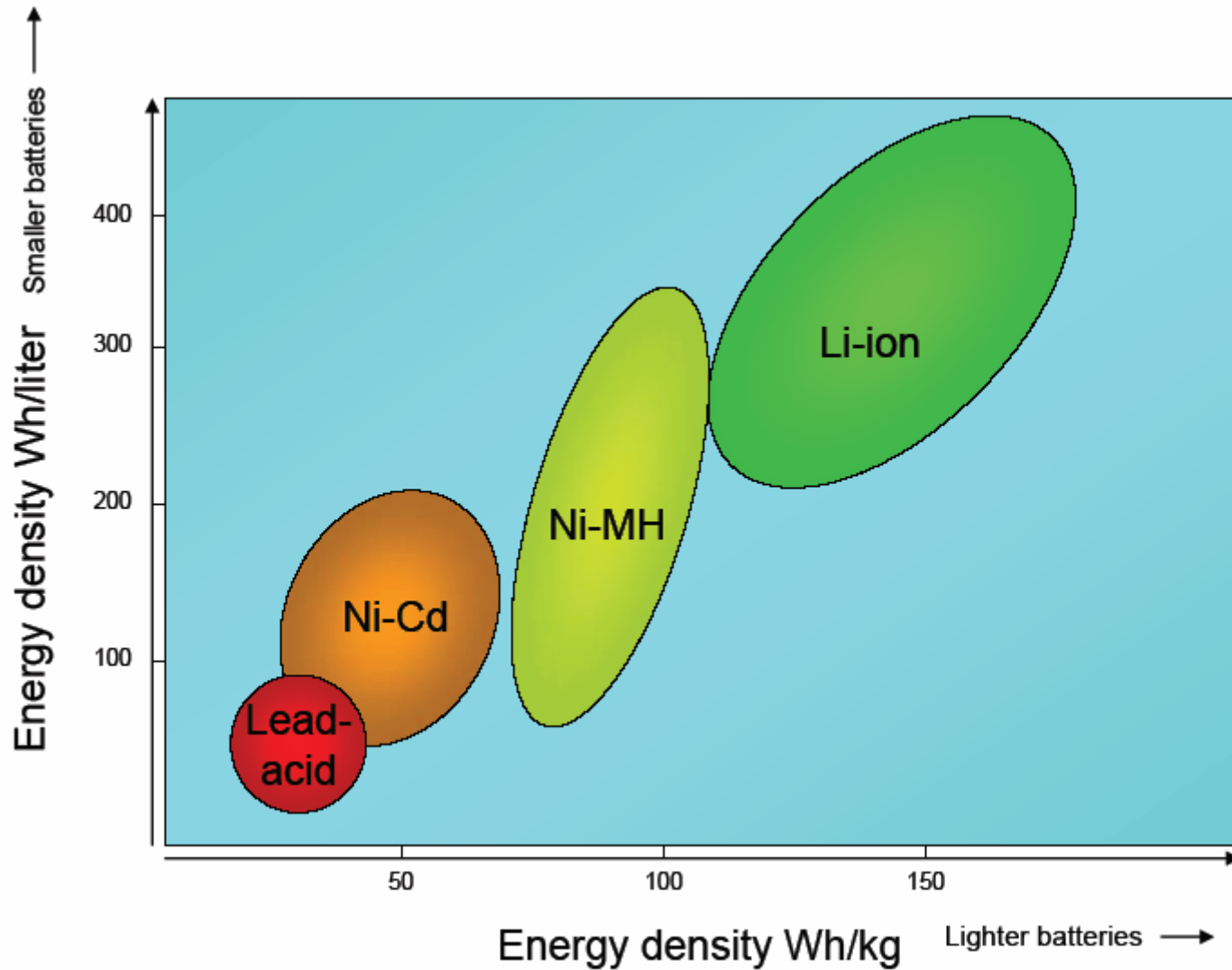
Universities /  
Institutes of  
technology

Energy Technology Centre  
for  
battery and fuel cells

Industry /  
Market



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## *Performance of battery systems*

	<i>Lead Acid</i>	<i>NiMH</i>	<i>Li-ion (Today)</i>	<i>Li-ion (Future)</i>
<i>Power W/kg</i>	400	1300	1500	2500
<i>Energy Wh/kg</i>	35	50	160	200
<i>Wh/dm<sup>3</sup></i>	90	150	400	600



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## *Market price of battery systems*

	<i>Lead Acid</i>	NiMH	<i>Li-ion (Today)</i>	<i>Li-ion (Future)</i>
<i>\$/kWh</i>	150	1000	500	300
<i>\$/kW</i>	10	40	50	20



## Hybrid Electric Vehicle Batteries (HEV)

- Low energy            0,6 – 2,0 kWh, 20 – 50 kg
- High power            1500 – 2000 W/kg
- Duty profile            +/- 10 % of rated capacity at 50 % DOD
  
- Today                    NiMH batteries
- Battery life            10 Years
- Cost                      3000 \$ per pack



## Plug-in Hybrid Vehicle Batteries

- High energy      6 – 16 kWh, 100 – 200 kg
- Low power        300 W/kg
- Duty profile      0 -70 % of rated capacity  
                          at 70 % DOD; +/-10% of rated capacity
  
- Driving range    20 miles, 32 km
- Cost                10 000 \$/pack



## Hybrid Vehicles, new market for rechargeable batteries

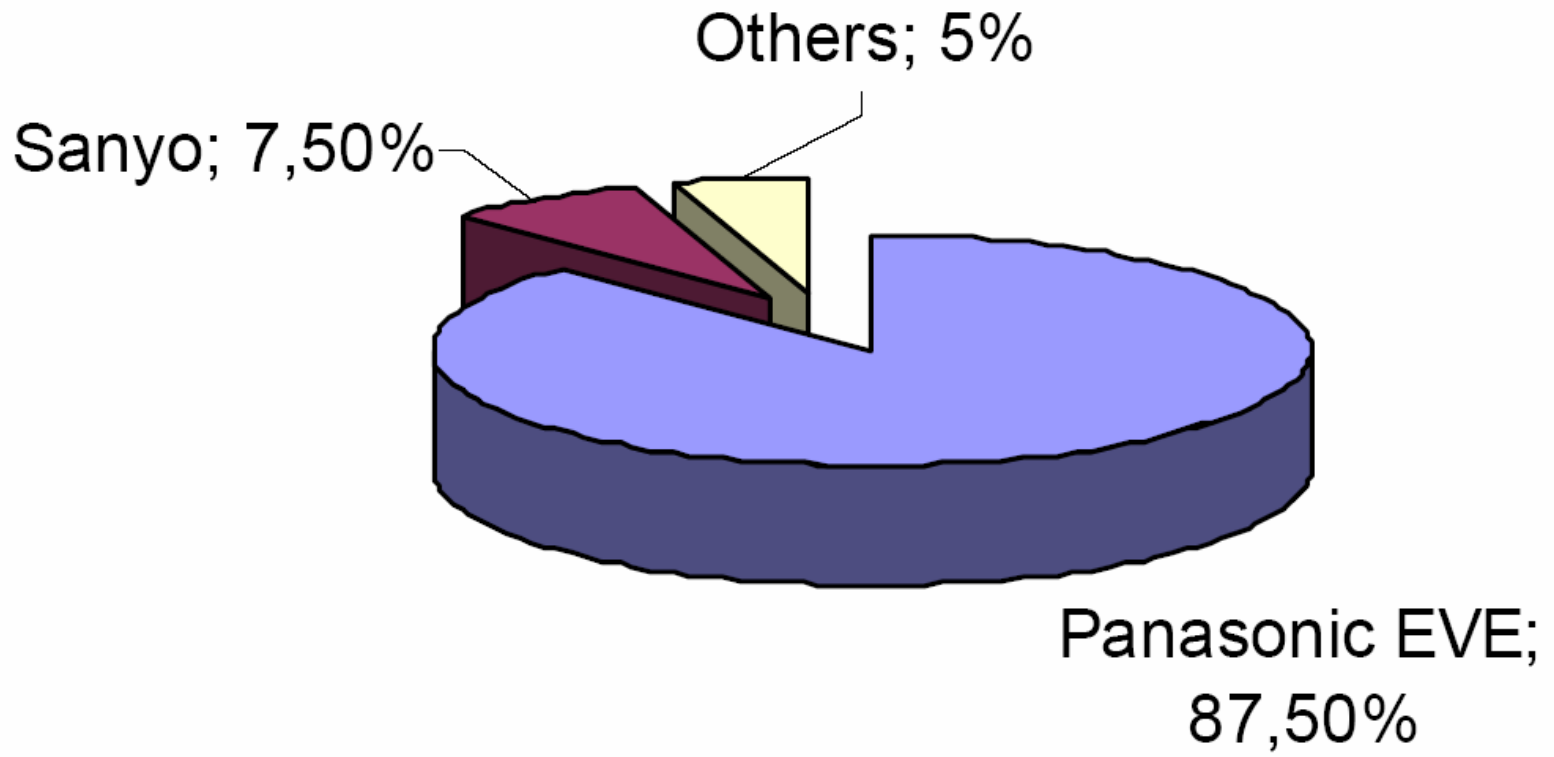
**300 \$/kWh, 100 cells, 20 Wh cell, 2 kWh, 600 USD**

Year 2006	400 000 Vehicles	40 Million cells	<b>240 MUSD</b>
Year 2012	2 200 000 Vehicles	220 Million cells	<b>1,32 BUSD</b>

Limited number of manufacturer in the World



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### **World Secondary Battery Market (\$B)**

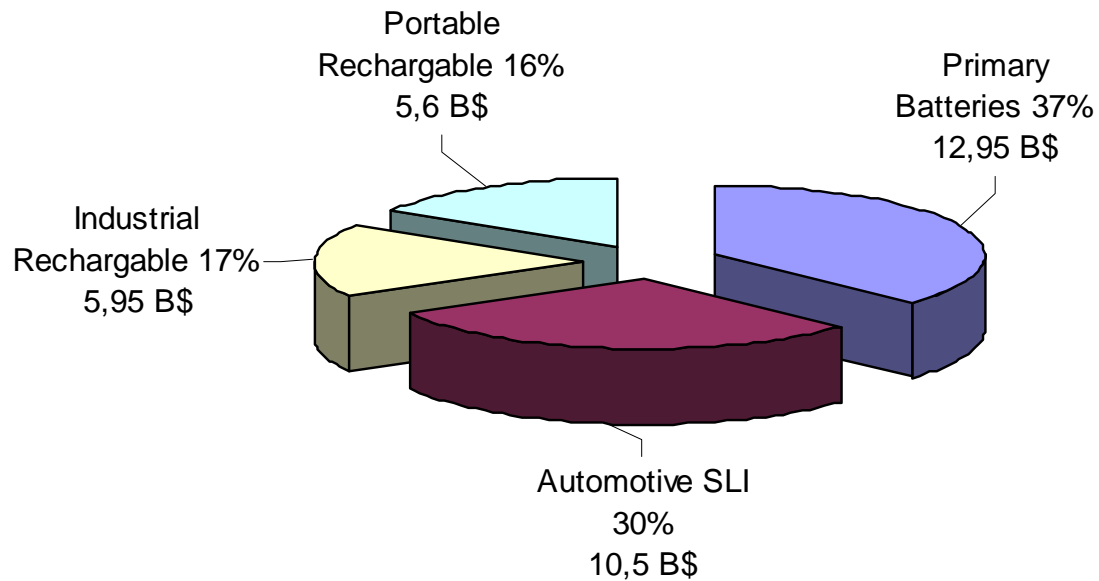
	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>CAGR</b>
Lead-acid	2.9	3.4	4.2	5.2	6.6	4%
Rechargeable Lithium	-	0.2	0.9	2.3	4.5	24%
Nickel-Cadmium	0.7	0.9	0.9	0.7	0.4	-2%
Nickel-Metal Hydride	0.0	0.2	0.4	0.6	0.8	17%
Other	0.1	0.2	0.3	0.6	0.9	14%
<b>Total</b>	<b>3.7</b>	<b>4.9</b>	<b>6.8</b>	<b>9.4</b>	<b>13.2</b>	<b>7%</b>

Source: Fredonia Group July 2001



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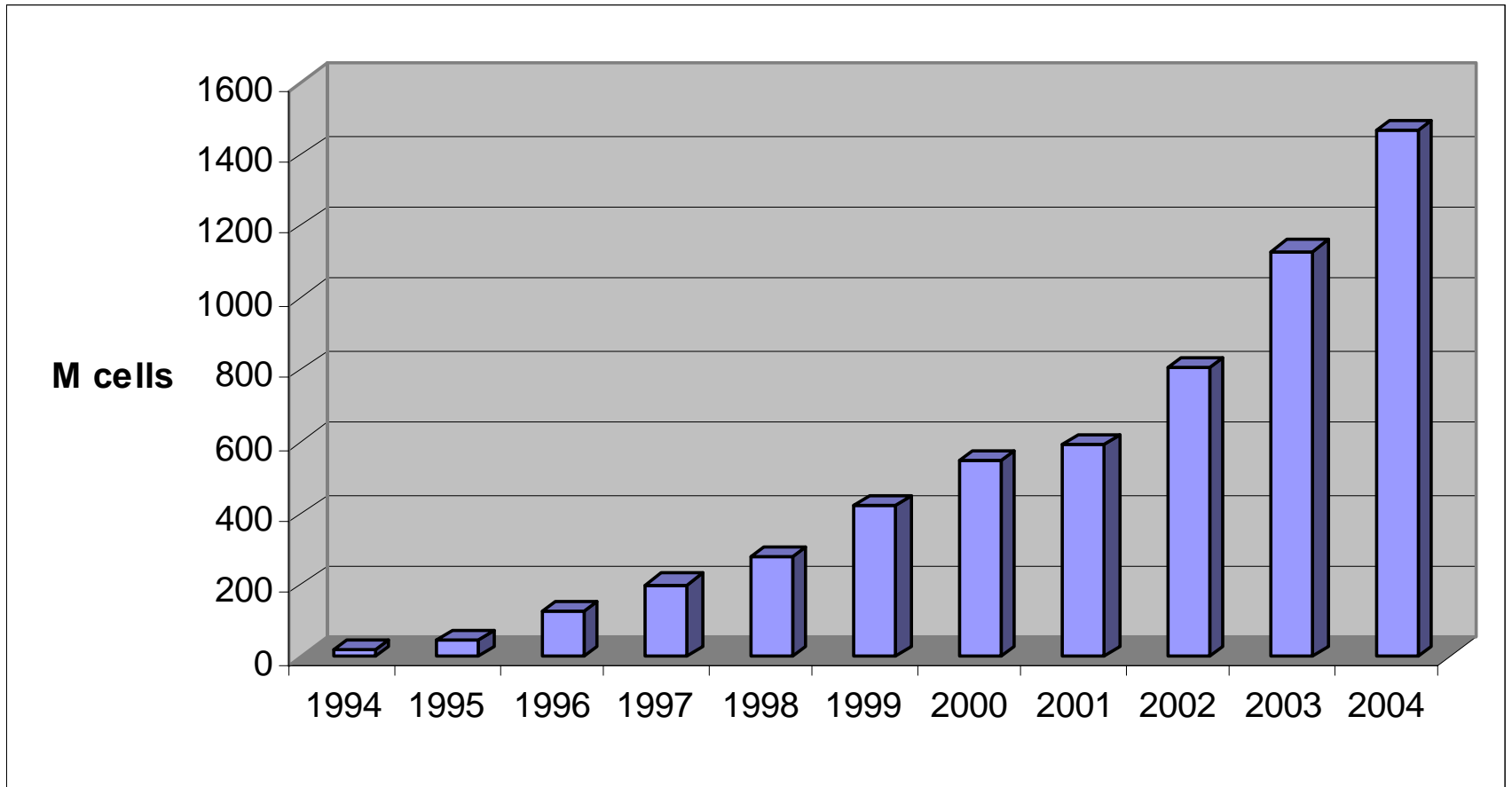
## World Battery Market 2004, 35 BUSD





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## Total sales of Li-ion cells



The introduction of larger Li-ion batteries in the HEV battery market requires that the following problems needs to be addressed and solved.

- **Safety:** thermal management of large systems is more difficult than for small systems, so cathode-related thermal runaway problems need to be addressed
- **Battery Cost:** need to be decreased in order to be competitive with commercial systems
- **Material Stability:** to be proven for long periods of stand-by or float charge



## **University of Uppsala**

Investigating and testing cathode material  
LiFePO<sub>4</sub>

## **Swedish Energy Agency**

Support the work with advanced battery systems

## **ETC Battery and FuelCells Sweden AB**

Commercialize advanced battery system, LiFePO<sub>4</sub>



## **Cathode material based on Phosphates $\text{LiFePO}_4$**

### **High thermal stability of $\text{LiFePO}_4$ and $\text{FePO}_4$ phases**

- Covalent P-O bonding stabilizing the structure versus  $\text{O}_2$  release
- Higher intrinsic safety of batteries using this material

### **Inexpensive components**

- Fe and  $\text{PO}_4$  are common components
- Possibility to lower costs associated to external safety devices



## **Cathode material based on Phosphates $\text{LiFePO}_4$**

### **Environmentally friendly**

- No toxic elements

### **High theoretical capacity of 170 mAh/g, (570 Wh/kg)**

### **Good electrochemical characteristics**

- Excellent Cycle Life
- High Tolerance to high and low-voltage abuse



## Nickel Metal Hydride (NiMH) batteries for Hybrid Vehicles

ETC Battery and FuelCells Sweden AB has negotiate a  
Purchase Agreement with Panasonic EV Energy  
NiMH batteries for Toyota and Lexus hybrid vehicles

Tier one supplier to Automotive industry in Sweden



# Battery systems for Hybrid Vehicles

Complete Battery Systems including;

- Battery Monitoring System

- Thermal Management

- Safety and other electrical components

- CAN Communication